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ABSTRACT

A field hearing on secondary science and mathematics (S/M) education focused on the growing problem of scientific and technical literacy and on scientific mathematics and science education problems in Oklahoma. Testimony presented at, discussions held during, and documentation related to the hearing are provided. Issues addressed included S/M teacher shortages, declining S/M achievement scores and enrollment in these areas, pre/in-service teacher education, results of the decline in scientific/technological literacy, and possible recommendations for resolving the problem (including government role). Speakers included Richard S. Nicholson, F. James Rutherford, Joseph Lipson, Eugene V. Smith, Donald Kellogg, Joseph R. Weaver, Harold Huneke, and Douglas B. Aichele. Supporting documentation (in appendices) includes a questionnaire related to a survey of mathematics education in Oklahoma and testimony of two classroom teachers; Harold D. Taylor (presented to the National Commission on Excellence in Education) and Sara E. Klein (president, National Science Teachers Association). (JN)

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SECONDARY MATH AND SCIENCE EDUCATION

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HEARING

BEFORE THE

SUBCOMMITTEE ON
SCIENCE, RESEARCH AND TECHNOLOGY

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

NINETY-SEVENTH CONGRESS

SECOND SESSION

MAY 7, 1982

[No. 169]

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[1] On assignment to Budget Committee for 97th Congress.

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SECONDARY MATH AND SCIENCE EDUCATION

FRIDAY, MAY 7, 1982

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to call, at 9:30 a.m., at Dale Hall, University of Oklahoma, Norman, Okla.; Congressman Dave McCurdy presiding.

Mr. MCCURDY. Let me take a moment before we start the hearing. I was going to introduce Dr. Bill Banowsky, the president of the University of Oklahoma, for a quick comment.

I invited the president to come by and make a couple of introductory remarks before we begin the hearing.

So, at this time, Dr. Banowsky.

Dr. BANOWSKY. Dave said a quick remark. Actually, I wanted to make a speech against these Congressmen who are trying to take all of our oil and gas tax away from us.

We have got big headlines in our papers today, fellows, that warn us against what you have come to do.

We have got two frostbelt Congressmen with us, Vin Weber of Minnesota, who doesn't have a lot of oil and gas production in his State, I understand, and Representative F. James Sensenbrenner of Wisconsin.

We are delighted to have you along with Ralph Hall from the great State of Texas. These are the three Members of the U.S. Congress, who along with our own product of whom we are very proud, Dave McCurdy.

Congressman McCurdy has taken the lead to make possible this important hearing on our campus, and I want to take the time now to welcome and mention by name the distinguished academic and other officials who are here and nonetheless, we are just as delighted to have you.

On behalf of the University of Oklahoma I would like to say how important I believe this subject is. During the 1970's we have seen a terrific increase in enrollments and majors in the fields such as business and engineering, and medicine and law—almost a vocationalism—almost an interest in a professionalism that is a terrific erosion of the sciences and the liberal arts.

We have seen a tremendous decrease in the number of majors in history and philosophy, in English and mathematics, and in sciences.

I think that is a step in the wrong direction. My own conviction is that we make a terrible mistake by forcing high school graduates

to choose a major field when they are 17 years old and then shovel them down some narrow tunnel of specialization simply where the bottom line is bucks. Everybody would be better off facing an unknown future to be as broadly trained as possible in the arts and sciences.

We should postpone this narrow specialization until graduate school, and give everybody the broadest possible background. So, the subject couldn't be more pertinent than it is.

The University of Oklahoma endorses it. We hope something can be begun here that can actually affect academic and national policy.

And on behalf of the University of Oklahoma, I am very pleased to welcome you. At 2 o'clock today we are having the dedication of the facility which to this point is the largest single construction project in the history of Oklahoma higher education: the grand doubling of our library and the Neustadt wing of our library. And I don't know what you are doing at 2, Congressman McCurdy, but if you could recess, why, I will get another chance to make another speech there.

We are delighted to have you. Let's express our appreciation to Dave McCurdy for this. [Applause.]

Mr. MCCURDY. Thank you, Dr. Banowsky. And with that we will officially begin this hearing this morning. I might comment that any opportunity we get to plug the university and to help them further their purpose, we will definitely take it.

I want to welcome all of the subcommittee members and staff and witnesses who have traveled to Norman for today's Science, Research and Technology Subcommittee Field Hearing on Secondary Science and Math Education. Testimony and discussion will focus on the growing problem of scientific and technical illiteracy. The critical shortage of qualified science and math teachers and solutions which involve the Federal, State and local governments, industry, academia and concerned private citizens. The primary focus of the second panel will be on the scientific math and science education problems of the State of Oklahoma, which I believe can be looked at as a case study for the rest of the country. Before we hear the testimony of our distinguished witnesses, I would like to make a few brief comments about this serious national problem.

We are facing a national crisis in science, math, and engineering education and an incredible shortage of engineering, scientific, and technical personnel. Not only has the quantity and quality of science and math education in our schools declined, but our schools are also faced with serious shortages of qualified science and math teachers. There has been a dramatic decline in the scientific and mathematical achievement of our young people. School districts are placing less emphasis on science and mathematics. Students are dropping out of courses earlier and performing more and more poorly on science and math achievement tests. Our educational system is the key to maintaining our leadership position in the world; it's a well-educated populace that has enabled us to advance faster and farther than any other country. Technology and innovation will be useless without a technically skilled workforce. No amount of money we spend on weapons will buy us security without men and women capable of using them effectively. It is essen-

tial that we address this issue now and that it be a cooperative, coordinated effort that includes all levels of government, industry and academia. One initiative that has been taken in Congress is the introduction of House Resolution 5254, the National Engineering and Science Manpower Act of 1982, sponsored by Representative Don Fuqua, chairman of the Committee on Science and Technology, and Representative Doug Walgren, chairman of this subcommittee. This legislation would establish a comprehensive Federal policy of engineering and science manpower. I want to commend our chairmen for their efforts and I urge my colleagues to join me in cosponsoring this legislation.

The testimony we hear today will prove very useful in the Science and Technology Committee's efforts to address science and engineering education and manpower problems, especially at the secondary school level, and can be an important first step toward renewing and strengthening our national commitment to excellence in science and math education. While specific improvements in elementary and secondary school curriculum should be the responsibility of State and local governments, I believe it is essential for the Federal Government to provide guidance to the States and develop an overall national strategy and policy for improving precollege science and math education. I appreciate all the hard work that my colleagues, staff and our witnesses have put into this hearing, and I am looking forward to hearing our witnesses' testimony.

With us today—and Dr. Banowsky made a quick introduction, and I would like to introduce them in more detail—is Congressman Jim Sensenbrenner from the great State of Wisconsin, who is a member of the full Committee on Science and Technology; Congressman Vin Weber from Minnesota, who is a member of the subcommittee which is hearing today; and, of course, my dear and close friend from just across the Red River, Congressman Ralph Hall from Texas.

Also, I would like to remind my colleagues and our witnesses that there is a luncheon immediately following this hearing in the Couch Center Cafeteria upstairs dining room. The luncheon will be followed by a conference on secondary science and math education, which will focus on math and science programs that work and elaborate further on public policy options.

But this morning, of course, is the hearing with the distinguished panel.

For members of the media, there will be a brief press conference immediately following the hearing, which will end at 11:45 this morning.

I would now like to turn to my colleagues and ask if they would like to make any opening remarks.

Mr. SENSENBRENNER. Thank you very much, Mr. Chairman. I would like to commend you for holding these hearings on a very important subject, that is, how to provide more scientists so that the United States will continue to enjoy its technological advantage over other nations of the world.

This is my first visit to Oklahoma, and until today I never knew of the hospitality I had missed. So, I thank my colleague, Mr. McCurdy, for inviting me here, and I hope to return sometime in the near future.

Frankly speaking, I have problems with the bill under discussion today. No one, myself included, can quarrel with the need to educate more high school science teachers, to pay them better so that they don't leave teaching and go into private industry, and to encourage more high school students to seek science and engineering degrees in college.

But I question the Federal Government's role in establishing a program which will have the effect of influencing the local school curriculum.

Local control of education in our country is one of the principals which has allowed public education to receive more money and more public support than in any of the other Western industrialized democracies. The more Federal intervention into the local school districts, the more setting of Federal priorities from Washington we will have, and the further we will get from local control.

As I see the major problem in science curriculum and math curriculum from the high school level, it is basically that our State legislatures and local boards of education around the country have not recognized the serious problem we are in.

It was learned in a recent study of State legislative curricular requirements that only half of the States require at least one science course before high school graduation. Five require two or more courses, and the rest mandates none.

Now it's no wonder this country is facing math and science illiteracy when the State mandated curriculum from our 50 State capitols have such glaring loopholes.

The second problem I have with the bill under discussion today is that it spends $50 million of the taxpayers' money for a program which does not guarantee a single additional science or engineering graduate.

Hundred billion dollar Federal deficits with the accompanying high inflation, high interest rates, and high unemployment are made of bills like these, even though they are introduced with the best of intentions and for the noblest of goals, they do add to the Federal budget deficit.

So, during the course of this hearing, I hope that the witnesses will address their remarks to two specific questions: First, why should the Federal Government get involved in this area at all when the setting of curriculum is done in State capitols and in local school board groups; second, how will this bill with its $50 million authorization in the creation of yet another committee guarantee that any high school student who is not already motivated in math or science will go on to get a science or engineering degree in college?

Again, I would like to commend Mr. McCurdy for holding these hearings and stimulating this discussion. And it certainly is a pleasure being here in Norman. Thank you.

Mr. McCURDY. Thank you, Mr. Sensenbrenner.

As you can tell, this is not a clear-cut issue. There is always a division of opinion. I think we will see—I think the testimony today will clearly indicate that there is a consensus on the nature of the problem. It is the question, again, of the method of solving or resolving this problem.

Mr. Hall, do you have anything?

Mr. HALL. Yes. Thank you, Congressman McCurdy. My distinguished colleagues, members of the staff, Dr. Nicholson, Dr. Rutherford, and Dr. Lipson, I will be very brief. I think from the standpoint of levity we might begin by saying that we don't all agree on any one thing.

I know a story about a boy who tried to please his mother with the girl he went with. And he went with about 25 different ones, and finally found one that looked exactly like his mother. And married her and brought her home, and his dad didn't like her. [Laughter.]

I see in this bill, not a Federal enemy, but a friend and supporter. And not intervention, but support, needed support, in an area that we are in very bad trouble in.

You know, it's generally accepted that production and industry lags at varying times. And it depends on the thrust: there you begin with a patent. You have your blueprints. You have an idea. The building of dies, and the gearing-up.

Now, such time lag is also applicable to science and to manpower problems that we have today, only the gear-up is a little bit different. It is a little longer and it takes more than a single board of directors or an assembly line.

All levels of government, industry, all fountainheads of knowledge have to cooperate and have to plan, and as we say in industry, absolutely have to "gear-up."

I know I do want to say that not just in the pursuit of excellence is what this bill portrays today, but in the pursuit of leadership. And this is a partisan statement.

Certainly Oklahoma, in its tradition, has sent us a man around whom we think we can build a Democratic Party, Dave McCurdy. And I am honored to be in his district, and in the tradition of the leaders that you have sent before, young, attractive, educated—and he wrote this last part of what I'm saying now [laughter], a man of great good humor, and one who can negotiate.

I am honored to be here, Dave. Thank you for letting me come to your district.

Mr. MCCURDY. Thank you, Congressman Hall.

Congressman Weber?

Mr. WEBER. Thank you, Mr. Chairman. And I would like to also thank all the people who have shown us such a warm welcome here this morning. Although we may have some partisan differences, it has been a great pleasure for me to serve on the Committee on Science and Technology with your Congressman. It's a great pleasure for me to be here today.

This is also my first visit to Oklahoma, and I'm enjoying it a great deal, and hope to come back sometime soon.

As my colleague, Mr. Sensenbrenner, pointed out, there's probably very little disagreement about the problem of science, engineering, and educational manpower.

But the question—and it's a very large question—is the appropriateness of a Federal response. And specifically, the appropriateness of the response that we are being asked to consider today, H.R. 5254.

Mr. Chairman, I have a prepared statement that I would like to submit for the record.

Mr. McCURDY. Without objection, it will be accepted.

Mr. WEBER. Like you, this is my first term in Congress and the recollection of my first campaign is pretty vivid in my mind. People told me when they sent me to Congress, that they wanted to see a change in the way the Government operated. They wanted to see a change in the way the economy was going, and a change in the way that we were conducting business in this country. Time and time again, I would talk to people who would say, "The problem is that the Federal Government is growing too large. It's regulating too much. It's spending too much. The bureaucracy is overbloated, and we have got to do something about that." And in my first term in Congress it's very easy for me to see exactly why that has happened, and how difficult it is going to be to turn it around.

One of the mistaken impressions that I had before I came to Congress was that Members of Congress are out there and constantly voting to spend precious Federal tax dollars on stupid ideas. It's not the case at all. I have found out sort of to my dismay, it's not that easy. You just can't tear up the stupid ideas and cut them out of the budget, and solve the problem.

There isn't a Federal program on the books that was not put there because people found a real problem and had a good idea of how to deal with it. We now face in this country a situation where we cannot possibly even fund all of the solutions necessary to the real problems, even though there may be a good solution and appropriate responses.

We have reached a limit to some of our resources as a nation and we have to make some very hard decisions. That is, I guess, why I have some questions—and I don't want to say that I am absolutely opposed—but I do have some questions about H.R. 5254 and the appropriateness of that response. Certainly we have a science and engineering manpower problem in this country, but also, surely, that problem has been building for many, many years.

The testimony before our Subcommittee on Science and Technology Committee indicates that this is a problem that has been growing for the better part of a decade or more. During that period of time the Federal Government and State government's investments in education have steadily increased.

In view of that, I find it somewhat frustrating that we are told that the whole cause of that problem is a rather recent cutback in Federal support for some fairly narrowly defined programs.

And, Mr. Chairman, I would point out that I come from the State of Minnesota which has the largest per capita investment in education of any State in the Nation. We believe in supporting education.

I have no question about the importance of putting tax dollars into education. But in view of the fact that we have seen these educational problems developing during the period of escalating support at the Federal, State, and local levels, I just have to ask the question, is this really the only problem or are there some other factors that are more deep-seated in the American society and structure of our Government, such as my colleague from Wisconsin discussed, that we maybe should address.

Finally, I guess, I will make a point that President Banowsky referred to what I'm sure is a very hot issue here in Oklahoma, which is the movement in the Federal Government to fund new Federal revenues by taxing or extracting additional revenues from the oil and gas industry here in Oklahoma and Texas and some of the other energy producing States. It's a very clean political issue in my State.

I want to assure you I haven't jumped on that bandwagon quite yet, but there is a very powerful support behind it in my State. I can certainly understand why the folks in Oklahoma would be very concerned about that.

I suspect if I would ask a group of people in this room why you would be concerned about that, you would tell me something to the effect that it is your resources and the Federal Government doesn't really have any right to jump in there and take them away.

In view of that, is there not some irony in discussing today a solution to the problem which requires additional Federal expenditure, Federal expenditures that must come from taxes?

The people in my State feel that they are pretty well taxed already, and we face serious economic problems. And while I sympathize very much with the concern in this State about taking more taxes out of Oklahoma to pay for Minnesota's problems, I also think that before we start adding additional bureaucracies and additional expenditures to the Federal budget we should ask ourselves very seriously where we expect the tax revenues to come from that are going to pay for those programs.

So, Mr. Chairman, it is a pleasure for me to be here and I am anxious to hear the testimony of witnesses that you have assembled for us today, but I also think that we also have to view this whole cycle of engineering manpower problem in a larger context and ask ourselves, is this really the appropriate response since it entails probably an increase in the same regulation, bureaucracy, and Federal spending that the voters in my last election said they wanted to see reversed. Thank you, Mr. Chairman.

[The prepared statement of Mr. Weber follows:]

WASHINGTON HAS RARELY BEEN WITHOUT A CRISIS. IN FACT, WE USUALLY HAVE MORE THAN OUR SHARE. NOT THAT SOME OF THEM ARE NOT REAL; ITS JUST THAT SOME OF THEM ARE MORE REAL THAN OTHERS, AND SOME OF THEM DON'T BELONG IN WASHINGTON -- NOT AT LEAST IF WE WANT TO GET THEM SOLVED.

THE PRECOLLEGE SCIENCE EDUCATION CRISIS HAS HIT WASHINGTON. THIS SUBCOMMITTEE, MORE THAN OTHERS IN THE CONGRESS, IS VERY WELL AWARE OF THE PROBLEM. WHILE THERE IS PERHAPS SOME DISAGREEMENT ON WHAT STEPS TO TAKE, THERE IS A CONSENSUS THAT THE CURRENT ATTENTION TO THE PROBLEM IS DESERVED. SOME EXPERTS ARE AFRAID THAT WE WILL OVERREACT; SOME ARE AFRAID WE ARE NOT DOING ENOUGH.

DR. RUTHERFORD, WHO IS TESTIFYING TODAY, STATED AT AN EARLIER SUBCOMMITTEE HEARING THIS FEBRUARY THAT THE "FEDERAL GOVERNMENT IS RETREATING AND APPEARS TO BE ABOUT TO ABANDON ALTOGETHER ANY SERIOUS EFFORT TO HELP UPGRADE THE QUALITY OF AMERICAN SCIENCE EDUCATION."

WHAT IS THE BASIS FOR THIS STATEMENT, AND WHAT IS THE PROPER ROLE OF THE FEDERAL GOVERNMENT IN PRECOLLEGE EDUCATION?

THIS SUBCOMMITTEE HAS HEARD A GREAT DEAL OF TESTIMONYON THE SCIENCE EDUCATION PROBLEM IN THIS COUNTRY. FROM WHAT I HAVE HEARD THE PROBLEM GOES MUCH DEEPER THAN RECENT REDUCTIONS IN FEDERAL FUNDS TARGETED FOR SCIENCE EDUCATION. IN MY OPINION, THE MOST SERIOUS PROBLEM WE FACE IN PRECOLLEGE SCIENCE EDUCATION IS THE STEADY DECLINE OF SCIENCE REQUIREMENTS FOR HIGH SCHOOL GRADUATION.

IN TESTIMONY HEARD BEFORE THIS SUBCOMMITTEE EARLIER THIS YEAR,

IT WAS LEARNED THAT IN A RECENT STUDY OF STATE-LEGISLATED CURRICULA SHOWS THAT ONLY HALF OF THE STATES REQUIRE AT LEAST ONE SCIENCE COURSE BEFORE HIGH SCHOOL GRADUATION, FIVE REQUIRE TWO OR MORE COURSES, AND THE REST MANDATE NONE.

THIS STEADY DECLINE HAS BEEN OCCURING FOR YEARS. IT IS NOT A RECENT PHENOMENON OF THIS ADMINISTRATION AS MANY WOULD HAVE US BELIEVE. ANYONE WHO FEELS THAT THE RECENT REDUCTION IN SCIENCE EDUCATION FUNDING AT THE NATIONAL SCIENCE FOUNDATION IS A ROOT CAUSE, OR WOULD LIKE TO IMPLY THAT IT IS -- IS SUFFERING FROM THEIR OWN EDUCATION DEFICIT. FEDERAL FUNDING IS NOT THE PRIMARY ISSUE HERE.

WE HEAR THAT THE SOVIETS AND OTHER EASTERN BLOC NATIONS HAVE TOUGHER SECONDARY SCHOOL GRADUATION REQUIREMENTS AND MORE DEGREE GRADUATES IN ENGINEERING AND OTHER TECHNICAL PROFESSIONS. THE REASON IS SIMPLE, IN A TOTALITARIAN SOCIETY THE FEDERAL GOVERNMENT DEMANDS THAT THE SCHOOLS PRODUCE THE DESIRED QUANTITY (AND WHO CAN SAY ABOUT THE QUALITY?). I DON'T THINK ANY OF US HERE WANT THE FEDERAL GOVERNMENT TO BECOME THAT INVOLVED!

IF OUR YOUNG CITIZENS ARE GOING TO BE BETTER PREPARED FOR AN INCREASINGLY SCIENTIFIC AND TECHNOLOGICAL SOCIETY, LET ALONE FOR ADVANCED TECHNICAL DEGREES, THEN STATE GOVERNMENTS AND LOCAL SCHOOL AUTHORITIES ARE GOING TO HAVE TO MAKE SOME FUNDAMENTAL CHANGES AT THE LOCAL LEVEL.

THE FEDERAL GOVERNMENT SHOULD PROVIDE AN OPEN AND FREE EDUCATION TO ALL OF ITS CITIZENS. IT SHOULD NOT AND CAN NOT SAY WHAT THAT EDUCATION SHOULD BE. THAT IS THE RIGHT AND RESPONSIBILITY OF THE INDIVIDUAL AND HIS OR HER COMMUNITY.

THE RECENT REDUCTION OF FEDERAL FUNDS FOR SCIENCE EDUCATION IS NOT THE PROPLEM, AND SIMPLY PROVIDING MORE TAXPAYER DOLLARS IS NOT T.E ANSWER.

WHAT IS NEEDED IS A FIRM COMMITMENT FROM SCHOOL BOARDS AND STATE LEGISLATURES TO UP-GRADE THEIR SCIENCE REQUIREMENTS, MAKE FACULTY SALARIES COMPETITIVE WITH THE PRIVATE SECTOR, AND INCREASE TEACHER TRAINING. CONCERNING THIS LAST POINT, THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (AAAS) HAS ALREADY BEGUN SEVERAL PROMISING INITIATIVES IN THIS AREA.

A STRONG FOUNDATION OF LOCAL AND STATE COMMITMENT TO A STRONG SCIENCE CURRICULUM, ALONG WITH CRUCIAL SUPPORT FROM PRIVATE INDUSTRY AND NATIONAL PROFESSIONAL ORGANIZATIONS LIKE THE AAAS, WILL PROVIDE THE NECESSARY FRAMEWORK FOR EFFECTIVE FEDERAL ACTION AND LEADERSHIP.

FAR FROM ABANDONING ANY SERIOUS EFFORTS TO SOLVE THE PROBLEM, THE FEDERAL GOVERNMENT, THROUGH THE NATIONAL SCIENCE BOARD, HAS ESTABLISHED THE COMMISSION ON PRECOLLEGE EDUCATION IN MATHEMATICS, SCIENCE, AND TECHNOLOGY.

THE PURPOSE OF THE COMMISSION IS TO DEFINE A NATIONAL AGENDA FOR IMPROVING MATHEMATICS AND SCIENCE EDUCATION IN THIS COUNTRY. IT WILL DEVELOP AN ACTION _LAN THAT WILL INCLUDE A DEFINITION OF THE APPROPRIATE ROLES OF FEDERAL, STATE AND LOCAL GOVERNMENTS, PRO_ FESSIONAL AND SCIENTIFIC SOCIETIES, AND THE PRIVATE SECTOR IN ADDRESSING THIS NATIONAL PROBLEM. EXPECTED OUTCOMES ARE THE IDENTIFICATION OF THE STEPS TO BE TAKEN, THE ASSIGNMENT OF RESPONSIBILITY FOR ACTION, AND A TIME TABLE FOR THEIR ACCOMPLISHMENT.

TO SOME IT MAY APPEAR THAT THIS CRISIS HAS LEAPT UPON US; IT HASN'T. A LONG-TERM PROBLEM REQUIRES MORE RESPECT THAN SHORT-TERM SOLUTIONS -- ESPECIALLY WHEN THOSE SOLUTIONS ARE DEFINED AS SIMPLY PUMPING IN MORE FEDERAL DOLLARS.

IN CONCLUSION, I MIGHT SAY THAT I AM HERE NOT SO MUCH TO TELL YOU WHAT WE ARE DOING (THOUGH I HAVE ALREADY DONE SO), BUT TO HEAR WHAT YOU ARE DOING, AND WHAT YOU PLAN TO DO.

Mr. MCCURDY. Thank you, Mr. Weber.

I think the panel has seen that there is a number of questions raised about the nature of the problem and what are some of the possible solutions. I might add quickly that for my Republican colleagues from the North that we have arranged and invited them to view an oil and gas rig west of town here, before they leave this afternoon on the airplane. And I am sure that will be very enlightening for them——

Mr. SENSENBRENNER. Just for the record, I was one of two Wisconsin Congressmen that voted against the windfall profit tax. (Applause.)

Mr. MCCURDY. That indicates that not all from the Midwest are ignorant on energy issues as some would believe. [Laughter.]

Mr. WEBER. As long as we are getting on the record, I was not here when it was voted on, but I did oppose it in my campaign. I wanted to get that on the record so I could get out of here safely. [Laughter.]

Mr. MCCURDY. At this point I would like to thank everyone from the school systems throughout the State of Oklahoma and the universities who are here today. And at this point I will turn to our first witness, Dr. Richard Nicholson, who is the Executive Director of the Commission on Precollege Education in Mathematics, Science, and Technology of the National Science Foundation.

Dr. Nicholson, welcome to Oklahoma, and we certainly appreciate your attendance and welcome your statement at this time.

STATEMENT OF DR. RICHARD S. NICHOLSON, EXECUTIVE DIRECTOR, NATIONAL SCIENCE BOARD COMMISSION ON PRECOLLEGE EDUCATION IN MATHEMATICS, SCIENCE, AND TECHNOLOGY

Dr. NICHOLSON. Thank you, Mr. Chairman. Mr. Chairman, members of the committee, distinguished guests and visitors; it is a real privilege and pleasure for me to be here today. I believe that today's hearings—and the conference that the chairman has organized for this afternoon—address an issue whose importance would be hard to overestimate. It is not an exaggeration to state that our Nation's future economic welfare and security are at stake. So, Mr. Chairman, the topic is a most important one, and I am honored to be a participant in your hearings.

It is also a privilege for me to come here to represent a commission that has just been established by the National Science Board to deal with some of the issues that will be discussed today. I am Executive Director of the new Commission. Prior to that I was Director of the Chemistry Division at the National Science Foundation.

Mr. Chairman, I have a prepared, written statement which, with your permission, I would like to submit for the record, and, if I may simply summarize briefly some of the main points.

Mr. MCCURDY. OK.

Dr. NICHOLSON. As I said, I would like to describe for you the Commission that was established about 2 weeks ago by the National Science Board. The National Science Board is the policymaking body of the National Science Foundation.

Obviously, since the Commission is only 2 weeks old, I cannot list for you any accomplishments of the Commission. Nor can I identify for you in any detail the specific issues they will focus on, or how they will go about their business. But I think I can give you some of the ideas and perspectives that led to the establishment of the Commission by the Board. And, perhaps if I'm lucky, I can even dispell some of the skepticism that is naturally associated with Washington-originated committees.

The thinking that led to the formation of the Commission started in earnest last summer during discussions between the National Science Board and the Director of the National Science Foundation, Dr. John Slaughter. It is fair to state that these discussions initially were driven by the budget reductions that occurred in NSF's science education activities. But as the discussions evolved, the view developed that the problems were deep and pervasive and, indeed, much broader than merely a budget issue for the National Science Foundation.

As the Board discussed this matter, they came to the view that there already exists a great deal of evidence—some of which you have stated, Mr. Chairman—that demonstrates rather clearly the nature and extent of our problems. My own view is that indeed, one can agree fairly easily on the definition of the problems because of all the evidence that now exists. There have been, I guess, some 30 studies now, all of which pretty much lead one to conclude that this country's performance in precollege math and science education has seriously declined during the past 10–15 years.

I believe, however, that when one asks about the causes, or about appropriate changes at any level, or what is the proper role for the Federal Government, then there is less agreement.

And so, the Board decided to establish a Commission. But on the premise that it would not conduct yet another study of the problems. It is not to generate the 31st report telling us what the problems are. Rather, the Commission will try to do things that will help develop the lacking concensus I referred to. It will try to develop reasonable solutions for the country, with full recognition of the nature of our educational system, and the fundamental responsibility of State and local governments.

Mr. Chairman, I brought with me copies of the press release and a fact sheet describing the Commission and have made them available to all of your conferees. I invite them—indeed, I would urge those persons in the audience who are concerned about these issues moreover, to give advice and ideas to the Commission. I would like to ask for volunteers who would be willing to work with the Commission. Because I think that if the Commission is to accomplish anything truly useful and lasting, the process must involve individuals at the local level, it must seek their advice and their ideas. Mr. Chairman, we would like, in a meaningful way, for individuals like those in your audience today, to become the co-authors of the Commission's final recommendations.

Mr. Chairman, I will not repeat all of the evidence, because you very eloquently stated much of it in your opening remarks. And I believe some of the other panelists will provide additional examples. And, indeed, in the Commission fact sheet, we have listed many of them as well, in part, actually to remind ourselves that we

know the nature and dimensions of the problems and therefore we should not spend precious time studying them.

But I did bring with me two graphs that I would like to mention. I believe you have copies of these figures on your table. These are two examples that are most easily visualized graphically.

One of them looks historically at what has happened, and the other looks in a forward direction.

The first is a plot of SAT scores over a long period of time; about 20 years, actually. These data, I think, are all too depressingly familiar to everyone here. We know that there has been a long and steady decline and this is just one of many pieces of data that tell us the same thing.

I believe it also is the case that over this period of time expenditures on a per student basis, in constant dollars, have risen by almost 40 percent. This suggests to me that money alone is not the answer to our problems; there are many other important dimensions as well.

The other figure I have is useful in looking into the future. We all like to look into the future and make projections. And we all understand the difficulty and fallibility of doing that.

But there is one kind of data where one can, I think, look at the future data that are not subject to as much fallibility. These are demographic data.

The next chart is simply a plot of the so-called 18-year-old cohort, that is, the number of 18-year-olds who will reside in this country over the next 15 years or so.

And as you can see, the curve drops steeply and systematically by a staggering 25 percent over the next 15 years.

The cohort peaked just last year, so we are now only on the very front end of seeing any effects.

Here it is important to recognize that, being demographic data, the numbers can be decreased further by things like war and pestilence, but they cannot be increased by anything but, I guess, an act of God; not even, with all due respect, an act of Congress [laughter] can increase them.

Full recognition of this phenomenon is important as we think about possible solutions and plans for the future. The sharply declining 18-year-old population surely will have a large impact on our educational system, both at the college and precollege level.

Just to mention one example, we often hear as a suggested solution the raising of college entrance requirements. They have been lowered in the past, and if we were now to raise them again, high schools would follow suit. But I wonder, when one recognizes the financial straits of many of the colleges in this country, just how likely are they to raise standards when competing for a shrinking pool of tuition dollars?

Mr. Chairman, I would like to conclude by thanking you again for inviting me to these hearings. And, again, I want to invite those in your audience, who are the ones with experience at the working level, to contact me at the National Science Foundation if you have ideas and would like to work with us.

[The prepared statement of Dr. Nicholson follows:]

STATEMENT OF
DR. RICHARD S. NICHOLSON
EXECUTIVE DIRECTOR, NATIONAL SCIENCE BOARD
COMMISSION ON PRECOLLEGE EDUCATION IN
MATHEMATICS, SCIENCE AND TECHNOLOGY

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE:

IT IS MY PLEASURE TO APPEAR BEFORE YOU THIS MORNING AT THE UNIVERSITY OF OKLAHOMA. I INTEND TO BE BRIEF IN MY COMMENTS. IN MY NEW CAPACITY AS EXECUTIVE DIRECTOR OF THE NATIONAL SCIENCE BOARD COMMISSION ON PRECOLLEGE EDUCATION IN MATHEMATICS, SCIENCE AND TECHNOLOGY, I LOOK UPON THIS HEARING MORE AS AN OPPORTUNITY TO LISTEN TO THE TESTIMONY OF OTHERS. I WILL THEN BE ABLE TO MAKE THIS INFORMATION AVAILABLE TO THE COMMISSION MEMBERS AND STAFF.

THERE IS NO QUESTION THAT MATHEMATICS AND SCIENCE EDUCATION AT THE ELEMENTARY AND SECONDARY LEVELS IS FACING SEVERE PROBLEMS. IN THE PAST FEW YEARS, A NUMBER OF STUDIES HAVE POINTED OUT THOSE PROBLEMS. ALL THESE STUDIES POINT VERY CLEARLY TO THE SYMPTOMS OF THE PROBLEMS IN SCIENCE AND MATHEMATICS EDUCATION AT THE ELEMENTARY AND SECONDARY SCHOOL LEVELS:

-- CRITICAL SHORTAGES NATIONWIDE OF SECONDARY SCHOOL SCIENCE AND MATHEMATICS TEACHERS;
-- DECLINING PERCENTAGES OF STUDENTS TAKING SCIENCE AND MATHEMATICS COURSES;
-- DECLINING LEVELS OF ACHIEVEMENT OF HIGH SCHOOL GRADUATES AS EVIDENCED BY STEADILY LOWER SCORES ON STANDARDIZED NATIONAL TESTS;
-- FEWER MATHEMATICS AND SCIENCE REQUIREMENTS FOR HIGH SCHOOL GRADUATION;
-- FEWER MATHEMATICS AND SCIENCE REQUIREMENTS FOR COLLEGE ENTRANCE; AND
-- INCREASE OF REMEDIAL COURSES IN MATHEMATICS, NEEDED BY UNDERGRADUATE ENGINEERING STUDENTS.

THESE PROBLEMS RAISE QUESTIONS ABOUT THE ADEQUACY, IN QUALITY AND IN NUMBERS, OF THE POOL FROM WHICH FUTURE SCIENTISTS AND ENGINEERS ARE DRAWN. IN THE UNITED STATES, THE 18-24 YEAR OLD AGE GROUP IS DECLINING IN PROPORTION TO THE TOTAL POPULATION. AS THE POOL OF STUDENTS FROM WHICH WE DRAW THE NATION'S FUTURE SCIENTISTS AND ENGINEERS GETS SMALLER AND EARLY DROPOUTS FROM SCIENCE AND MATHEMATICS CURRICULAE INCREASE, ONE CAN PREDICT SHORTAGES OF QUALIFIED SCIENTISTS AND ENGINEERS IF NO CORRECTIVE ACTION IS TAKEN. THE STATE OF OKLAHOMA IS INDEED FORTUNATE IN THAT FOR THE PAST 10 YEARS SCIENCE ENROLLMENT AS A PERCENTAGE OF ALL ENROLLMENTS HAS REMAINED CONSTANT. IN THE FACE OF NATIONAL TRENDS SHOWING DECLINES IN HIGH SCHOOL STUDENT ENROLLMENTS IN SCIENCE, THIS RECORD IN OKLAHOMA IS A TRIBUTE TO ALL THOSE WHO HAVE LABORED TO BRING THIS ABOUT. BUT WITH THE INCREASING DEPENDENCE UPON TECHNOLOGY IN ALL SECTORS OF LIFE IN AMERICA, WE NOW NEED TO ASK IF THIS PERCENTAGE OF STUDENTS TAKING SCIENCE COURSES SHOULDN'T BE INCREASED.

THE OKLAHOMA STATE DEPARTMENT OF EDUCATION HAS JUST COMPLETED A SURVEY OF ALL SCHOOL SUPERINTENDENTS IN THE STATE AND IT APPEARS THAT THERE IS A SHORTAGE OF TEACHERS OF PHYSICS, CHEMISTRY, AND EARTH SCIENCES. OVERALL ABOUT 50% OF THE STATE'S SCIENCE TEACHERS ARE ON PROVISIONAL OR EMERGENCY TEACHING CERTIFICATES. WITH THE NEW STATE POLICY OF EARLY RETIREMENT, THESE SHORTAGES COULD BECOME MORE SEVERE.

INDUSTRY IN OKLAHOMA HAS NEED FOR SCIENTIFIC AND MATHEMATICALLY ABLE WORKERS. INDUSTRY IS ABLE TO PAY HIGHER SALARIES THAN ARE SCHOOL DISTRICTS AND MANY EXPERIENCED TEACHERS ARE LEAVING THEIR PROFESSION TO TAKE THESE BETTER PAYING POSITIONS. IF YOU CONSIDER THAT: THERE ARE ALREADY SHORTAGES IN SCIENCE AND MATHEMATICS TEACHERS; 50% OF THE STATE SCIENCE TEACHERS AT PRESENT DO NOT HAVE THE STANDARD TEACHING CERTIFICATE; INDUSTRY IS ATTRACTING MANY

EXPERIENCED TEACHERS WITH HIGHER SALARIES: AND TEACHERS WILL BE RETIRING AT AN EARLIER AGE. WHERE WILL OKLAHOMA FIND THE QUALIFIED TEACHERS TO FILL THE NEEDS OF THE SCHOOL SYSTEMS IN YEARS TO COME? IN THE FIRST SEMESTER OF THE CURRENT SCHOOL YEAR, ONLY 15 COLLEGE SENIORS TOOK THE REQUIRED OKLAHOMA TEACHER COMPETENCY TEST. IF DOUBLE THAT NUMBER TOOK THE TEST THIS SEMESTER, YOU WOULD HAVE 45 CERTIFIED TEACHERS. BUT WILL ALL OF THESE TEACHERS STAY IN OKLAHOMA? HOW MANY OF THEM WILL BE QUALIFIED SCIENCE TEACHERS?

THIS PROBLEM IS NOT PECULIAR TO OKLAHOMA AS SHOWN BY A NEW NATIONAL SURVEY BY THE NATIONAL SCIENCE TEACHERS ASSOCIATION. NATIONWIDE, 50% OF THE TEACHERS HIRED IN 1981 COULD NOT QUALIFY FOR CERTIFICATION. IN MATHEMATICS AND PHYSICS, 43 STATES (OF 45 RESPONDING) REPORT SEVERE SHORTAGES OF TEACHERS. SO WE ARE TALKING ABOUT A SERIOUS NATIONAL PROBLEM THAT IS BECOMING MORE SEVERE.

EDUCATION IS A FUNCTION ASSIGNED TO STATE AND LOCAL GOVERNMENTS, BUT THE QUALITY OF THAT EDUCATION AS IT AFFECTS AMERICAN INDUSTRIAL PRODUCTIVITY, EMPLOYMENT OPPORTUNITY, SOCIAL PROGRESS AND NATIONAL DEFENSE IS A NATIONAL CONCERN. WE MUST FIND WAYS TO REVERSE THE DECLINE IN PRECOLLEGE EDUCATION IN SCIENCE AND MATHEMATICS.

THE FEDERAL GOVERNMENT CAN BE VERY HELPFUL IN ASSISTING STATES AND LOCAL GOVERNMENTS. IT CAN PROVIDE LEADERSHIP IN SPECIAL AREAS OF TECHNICAL SUPPORT. IT CAN EXERCISE LEVERAGE ON THE PROBLEM BY SERVING AS A CATALYST TO FOCUS STATE AND LOCAL GOVERNMENTS ON THE PROBLEMS OF PRECOLLEGE SCIENCE AND MATHEMATICS EDUCATION. ONCE STATES AND LOCAL GOVERNMENTS HAVE DETERMINED ON A CONCERTED PLAN OF ACTION, SOME FEDERAL FUNDS MAY BE DIRECTED TO CERTAIN AREAS OF SPECIAL WELL DELINEATED NEED.

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THE POSITION OF THE FEDERAL GOVERNMENT IS NOT ONE OF SHIRKING ITS RESPONSIBILITY, NOR IS THERE AN ATTEMPT TO ABROGATE FEDERAL INVOLVEMENT BECAUSE THESE PROBLEMS ARE NOT UNDER FEDERAL JURISDICTION. RATHER IN AN EFFORT TO DEFINE THE PROBLEM, TO DEFINE A PROPER ROLE FOR THE FEDERAL GOVERNMENT AND TO PRODUCE A SENSE OF UNITY AND A SENSE OF CONVICTION IN MISSION ON THE PART OF THE WHOLE SOCIETY TO ADDRESS THE PROBLEM COOPERATIVELY, THE NATIONAL SCIENCE BOARD, THE POLICY MAKING BODY OF THE NATIONAL SCIENCE FOUNDATION, ESTABLISHED THE COMMISSION ON PRECOLLEGE EDUCATION IN MATHEMATICS, SCIENCE AND TECHNOLOGY.

THE PURPOSE OF THE COMMISSION IS TO DEFINE A NATIONAL AGENDA FOR IMPROVING MATHEMATICS AND SCIENCE EDUCATION IN THIS COUNTRY. IT WILL DEVELOP AN ACTION PLAN THAT WILL INCLUDE A DEFINITION OF THE APPROPRIATE ROLES OF FEDERAL, STATE, AND LOCAL GOVERNMENTS, PROFESSIONAL AND SCIENTIFIC SOCIETIES AND THE PRIVATE SECTOR IN ADDRESSING THIS PROBLEM OF NATIONAL DIMENSION. EXPECTED OUTCOMES ARE THE IDENTIFICATION OF THE STEPS TO BE TAKEN, THE ASSIGNMENT OF RESPONSIBILITY FOR ACTION, AND A TIME TABLE FOR THEIR ACCOMPLISHMENT.

THE COMMISSION WILL SEEK THE ADVICE AND ASSISTANCE OF STATE AND LOCAL GOVERNMENTS, PARENTS, TEACHERS, AND OTHER GROUPS AND ORGANIZATIONS THAT ARE SPECIFICALLY CONCERNED WITH PRECOLLEGE EDUCATION IN MATHEMATICS AND SCIENCE. ALTHOUGH THE PLANS OF THE COMMISSION ARE NOT COMPLETE IT IS EXPECTED THAT IT WILL WORK WITH A NUMBER OF PANELS MADE UP OF PROFESSIONALS AND EXPERTS IN THE APPROPRIATE AREAS AND WILL INCLUDE LOCAL SCHOOL TEACHERS AND PARENTS. THE COMMISSION FINDINGS AND ACTION PLAN WILL NOT BE DEVELOPED IN A VACUUM BUT WILL INCLUDE VIEWS AND OPINIONS FROM THE FIELD.

THE FOUNDATION IS PARTICULARLY PLEASED THAT THE COMMISSION WILL BE CO-CHAIRED BY WILLIAM T. COLEMAN, JR., FORMER SECRETARY OF TRANSPORTATION AND NOW AN ATTORNEY OF CONSIDERABLE DISTINCTION; AND BY DR. CECILY CANNAN SELBY, CHAIRPERSON OF THE BOARD OF ADVISORS OF

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THE NORTH CAROLINA SCHOOL OF SCIENCE AND MATHEMATICS AND FORMER NATIONAL EXECUTIVE DIRECTOR OF THE GIRL SCOUTS OF AMERICA.

THE COMMISSION MEMBERSHIP COMPRISES NOT ONLY DISTINGUISHED SCIENTISTS, ENGINEERS, AND MATHEMATICIANS, BUT ALSO QUITE A NUMBER OF PEOPLE WHO ARE LAY PERSONS WITH RESPECT TO SCIENCE, MATHEMATICS AND ENGINEERING THOUGH CERTAINLY NOT LAY PERSONS WITH RESPECT TO INTEREST IN THIS ISSUE. SEVERAL OF THESE MEMBERS: GENERAL LEW ALLEN, JR., CHIEF OF STAFF OF THE U.S. AIR FORCE: DR. WILLIAM H. COSBY, JR., ACTOR AND ENTERTAINER: DR. ROBERT E. LAWSON, PRESIDENT OF SYSTEMS CONTROL, INC.: AND DR. GERALD D. LAUBACH, PRESIDENT OF PFIZER INC., HAVE LED VERY DISTINGUISHED CAREERS IN OTHER THAN ACADEMIC SURROUNDINGS.

THE COMMISSION IS SLATED TO LAST 18 MONTHS, TERMINATING ON OCTOBER 15, 1983. LET ME ASSURE YOU THIS IS NOT JUST A STUDY COMMISSION. THE COMMISSION IS CHARGED TO HAVE A SET OF CONSIDERED FINDINGS IN SIX MONTHS AND UPON ITS TERMINATION, A DEFINED NATIONAL AGENDA FOR IMPROVING MATHEMATICS AND SCIENCE EDUCATION IN THIS COUNTRY.

THE STATE OF PRECOLLEGE SCIENCE AND MATHEMATICS IS ON THE DECLINE BUT WE AT THE NATIONAL SCIENCE FOUNDATION HOPE THIS IS A TEMPORARY CONDITION. I SPEAK FOR DR. SLAUGHTER, THE DIRECTOR OF NSF AND DR. BRANSCOMB, THE CHAIRMAN OF THE NATIONAL SCIENCE BOARD WHEN I SAY THE FOUNDATION VIEWS THIS COMMISSION AS THE MOST IMPORTANT MATTER IT WILL DEAL WITH IN THE NEXT TWO YEARS. THE YOUTH OF OUR NATION MUST PROVIDE AN ADEQUATE HUMAN RESOURCE POOL FOR THE FUTURE SCIENTISTS AND ENGINEERS AND FOR A TECHNICALLY CAPABLE WORKFORCE IF WE ARE TO RETAIN TECHNOLOGICAL LEADERSHIP IN THE WORLD.

I LOOK FORWARD TO HEARING FROM THOSE WHO ARE HERE TO TESTIFY AND WELCOME THIS FIRST OPPORTUNITY TO GATHER INFORMATION FOR THE NSB COMMISSION.

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Mr. McCURDY. Thank you Dr. Nicholson. I appreciate you summarizing your statement because your statements and the graphs are submitted for the record. After the statements of Dr. Rutherford and Dr. Lipson we will be having further discussion and some questions regarding specifics, not only in your statement but in other areas. I appreciate your brevity.

Our next witness on the panel is Dr. F. James Rutherford who is the chief education officer of the American Association for the Advancement of Science, a very distinguished academician. Dr. Rutherford, we appreciate your coming to Oklahoma. Welcome to Oklahoma, and we appreciate your statement at this time.

STATEMENT OF F. JAMES RUTHERFORD, CHIEF EDUCATION OFFICER, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Dr. RUTHERFORD. Thank you, Mr. Chairman. It's a pleasure to be here.

I have had the privilege from time to time of giving testimony to Congress, but usually it is just across the street from where I live. So this is a very special privilege.

I couldn't help but be interested in the enthusiasm about the remarks on taxing Oklahoma oil properties. It's a good thing I'm not in Congress, because I might have voted the other way from what these folks were thinking.

I remember studying history in school at a time when Oklahoma was deemed one of the States without resources. There were a lot of things happening in the 1930's and other times in which the Nation shared, and some of my remarks come from my point of view that we are a very unusual nation but we are a nation. And we are a people. And we need to be together. Even while we learn to deal with our own individual problems in our own local communities, whether they are household or town or county or State, we are the same people. At times we have to think nationally, but that doesn't always imply or demand total Federal solution. It demands national thinking, however.

I, too, would like to submit testimony, Mr. Chairman, for the record, and make a few remarks.

Mr. McCURDY. OK.

Mr. RUTHERFORD. One of the things you learn in Washington is that you write things, speeches, and you never read them. It's a difficult sort of exercise, but that isn't too bad. I was in the Federal Government for a short while, and I learned there that whenever you sign a letter to send to somebody it has been written by somebody else for you. The letters you write personally always get signed by someone else a little higher. That's the way the things work in Washington: The good ones always get signed by somebody else.

This is a difficult topic to speak about. I would like to emphasize an overview or a grasp of the situation and not to speak about the nature of the problems, because I believe Dr. Lipson is going to do that, but to talk about the nature of solutions.

What's needed now is not so much another 2 or 3 years of talking about the problems, but getting on with the job. As a matter of

fact, it hasn't been 2 years for some of us; it has been a little over 10 years that we have been concerned with this developing problem.

One of the first things that needs to be emphasized is that we are dealing with a complex systemwide set of problems. It is not the problem of getting scientists, of getting engineers, of how to keep the universities viable, of how to improve school curriculums: It is a whole series of things. As soon as you accept the premise that we are dealing with a very complicated set of problems, in the name of science and engineering education, then I think you move to the point of understanding that there are no simple solutions.

And the first thing one must distrust is any one notion of what can be done to solve the problem: Raise college standards, improve teachers, develop better curriculums, improve equipment. None of those alone will work, and yet all are needed.

We have problems with the preparation and qualifications of teachers at all levels. Those that were prepared some time ago and are now teaching in our Nation's schools have an average age in the forties, and most of them haven't had retraining for 10, 15, or 16 years.

We have problems of inability to produce new sciences and mathematics teachers.

We have failed, and are moving backward in our ability to identify bright, talented young scientifically inclined people in junior high school and high school and to provide special training for them.

Our curriculum in science and mathematics is not improving and is not addressing the real needs of our youngsters. The expectations that we have for our youngsters, the expectations of parents, of the community, of the teacher, or the youngsters themselves, are out of phase with the circumstances we are in as a Nation, a Nation that depends on its superiority in science and technology.

We are not expecting enough of our students. The support system has broken down. You can put good teachers in the school, but if they haven't equipment, they haven't modern resources, they haven't the necessary technical materials, they can't keep up in their field, they have too many students, the system won't work; it's like any other.

That's the first point I would like to make. At every level, from preschool to elementary and secondary there are problems. Those are the most severe. Especially in the middle grades science education is a disaster in America. But at the undergraduate level we have a severe problem of out-of-date curriculums and failure to get the new technologies rapidly enough. Graduate problems we have heard about.

The second point I would like to make and emphasize from my testimony, is that this is indeed, a national problem. The strength of this Nation depends upon having first-rate scientists, outstanding engineers and a support system for scientists and engineers: technicians who can do the work that makes possible the work of scientists, and laboratories for them to do their work in properly. It demands workers who can work in our factories of the future, not letting that task go to Japan, Germany, France, workers who un-

derstand how to deal with modern science and technology and to think quantitatively.

We have to have people prepared to go into the military services who can operate that sophisticated equipment. We long ago opted for the defense system based not on overwhelming power quite as much as on the most subtle and sophisticated uses of modern technologies. But that takes educated people.

So, it's a national problem. And, yet, of course, the decisions are mostly made in thousands of places, the 50 States, 3,000 colleges and universities, more than 15,000 separate school boards and communities, private industry here and there, libraries, museums; each making its own decisions in its own way, in its own time scale.

I am skeptical that, in the 19th century, all those decisions will add up to a national policy having a focus.

Because we have a national problem we have to deal with it at all levels, all segments of government, the private and the public sectors. We have an unusual problem that other countries do not. We have to invent a system that brings us together as partners to work on the national scene.

If States decide that they don't care enough to insist upon a strong mathematical or scientific education for their children, it's not just that State that hurts because those children aren't going to stay there. They are going to work some place else in our country. So, we can't afford the willy-nilly.

Now, what about the Federal Government? That's what's in contention: What ought the Federal Government do? What can it do?

The first thing to clarify is the slogan that the Federal Government hasn't had much to do with education over the years, that Federal involvement with education was started recently and that it's bureaucratic and ineffective. That's all very nice because it's popular to run against Government. The last three Presidents have done it with some great success, but it may not be altogether accurate.

American public education didn't begin until the middle of the last century, so when our forefathers left education out of the Constitution, it was not a conscious decision that it would be in the province of the State. Public education did not exist, so it wasn't even thought about.

But in the last century the Federal Government invented the land grant university system which put together education and scientific research on a State basis, which turned American farming into agriculture; a scientific, technologically based system which is the envy of the world.

After World War II the United States decided it wanted to become a technical nation, and we didn't have educated people. We didn't have scientists. We didn't have engineers. We didn't have people to go into our factories. The GI bill of rights was only partly a gift to the American servicemen. It was a conscious effort to say, This Nation needs trained, educated people.

And if you look at Americans today, at those of us in our fifties, 45, 50, 55, 60 and say, "Where did they get their education?" You will find that an incredible number of the leaders of this Nation were educated with Federal dollars through the GI bill of rights. It made an enormous difference.

There are other examples, one of which is the National Science Foundation, one of the landmarks of education in the history of this Nation, emulated around the world.

What can the NSF and the Federal Government do. With tens of thousands of people making decisions, who will point the direction to go?

If the Federal Government says, Education and science and mathematics are so insignificant that we, ourselves, will not be a partner, it's hard to persuade States that are under the gun financially and the local people to pick up the tab.

I have been in lots of States that are cutting back also. They are not increasing funds for science and mathematics education.

A Federal role can provide leadership to focus on the issues, needs, concerns and can make some financial investment. It has always been a small amount but it has always been crucial.

A second point is that there are some things that the Federal Government is able to do that the States and localities have trouble with, and that do not interfere with local decisionmaking. Incidentally, the notion that the local school boards decide on the curriculum is an interesting but inaccurate piece of history generally. They make some decisions, such as requiring a year of science to graduate, even though the State doesn't require any science, and some things like that.

Do you know that the textbooks of America are almost all alike in that they are mostly produced in New York to satisfy the State of Texas and one or two other adoption States, and that this State and your school boards have almost nothing to say about what goes into the textbooks of America?

The notion that in each little town the school board creates the courses and the content is interesting, but simply not true. What the NSF can do at the Federal level is bring together scholars and teachers to create new kinds of ideas about content which then may or may not be used locally. In fact, during the 1960's and 1970's that's precisely what happended.

The Federal Government didn't require anybody to teach anything, but it provided some options that were different from those produced through traditional modes—and incidentally, the materials were published by companies that already existed, so it didn't even hurt them financially.

There are some other things. Let me give one example. The National Science Foundation, has easy working relationships with the scientists and engineers of the Nation; that's its business. Its business is not application, but dealing with science.

So certain kinds of programs NSF can operate. I will use as an example one that I think to discontinue is a desperate mistake. In the future, besides having a total support system we need to have bright young people go into technical careers. One way of doing that is to identify the talented ones when they are about 10, 11, or 12 years of age, or 13 or 14, and give them special support by getting them into university laboratories during the summers and other times to keep their interest alive. The NSF used to do that. Thousands of young people every summer were identified, selected by the universities, spent 6 to 8 weeks on the campus, and stayed alive and moving.

In principle that could be done locally, but it never has because locally there aren't the kinds of contracts, the resources, and the flexibility to put the scientific community in touch with young people. That's true also of programs for teachers and of several other programs.

Let me conclude, Mr. Chairman, by saying that, while I focused on the Federal role and small amounts in terms of dollars, although crucial in terms of leadership and special dealings with special problems, that doesn't relieve the States from responsibility.

I'm disappointed in the actions of certain States. Recently a State that does not require any high school science for graduation and only three semesters of junior high school science voted down a bill to increase the requirement to four semesters. That sort of State behavior disturbs me. But there's a role for everybody.

I would like to emphasize that the scientists and educators themselves, independently of State governments, Federal Government, what-have-you, have a role to play and they are now beginning to participate. With my testimony I have submitted from the AAAS a statement that really represents the efforts of over 200 scientific societies to begin to ask the question, "How can we as citizen scientists begin to contribute individually to the improvement of scientific education of all our young people" . . . not just those who are going to be scientists, but all of your young people.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Rutherford follows:]

TESTIMONY
PRESENTED BY
F. JAMES RUTHERFORD
CHIEF EDUCATION OFFICER
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Thank you for permitting me to testify before you on what I regard as one of the most urgent matters facing the American people today, namely, the quality of science, mathematics, and engineering education throughout our country.

While I speak for myself and the American Association for the Advancement of Science, in the preparation of these remarks I consulted widely with other scientific societies, science and mathematics teaching associations, higher education associations, representatives of school boards, school administrators, science and mathematics teachers, college and university scientists, and scientists and executives from buisness and industry.

As I spoke to these individuals a unanimity of opinion emerged: science and mathematics education is in rapid decline in the United States. Furthermore there is widespread belief that the price of this decline to the Nation is prohibitive, since nothing less than a dangerous undermining of our economic health, productivity, and national security is the inevitable consequence.

Our industrial competitors, both friendly and hostile, have committed themselves to the advancement and aggressive use of modern technology to insure their position in the world. Not only fully industrialized nations, such as the Soviet Union, Japan, Germany, and France, but also many developing countries, such as the People's Republic of China and Brazil, are investing heavily in science education for all of their students. They know that it takes not only a steady flow of scientists and engineers, but also technologically literate workers and leaders across the full spectrum of occupations to flourish as a strong and technically sophisticated nation.

Everywhere I have turned, not only in Washington, but in many states across the country, I have found our science educational system deteriorating, especially at the precollege level. The complexities of relationships within the system make the reversal of this trend terribly difficult. On the one hand, the <u>need</u> for strong science, mathematics, and technological education is <u>national</u>. Yet, on the other hand, <u>action</u> must be taken in tens of thousands of separate school districts, at thousands of individual colleges and univer-

sities, in fifty different states, and by a complex private sector made up of legions of independent companies and organizations. Clearly, the solution to this national crisis is to form and energize a national partnership--a cohesive, coherent, and determined effort at all levels and in all sectors. Individual schools, colleges and corporations, and each and every state will play an essential role, but the role of the federal government is unique and absolutely necessary.

The deterioration of our science education system is evidenced by falling test scores, a retreat from the study of science and mathematics at all levels by students, and the increasing difficulty business executives have in finding enough technically skilled workers. When we look at the system, this is what we see:

- As the school population decreases in the next two decades, it will become increasingly difficult to maintain an adequate supply of highly qualified scientists and engineers. To address this shortfall we need to increase our efforts to recruit professionals from an extended pool of American citizens capable of becoming scientists and engineers, a pool, that is, that includes a much greater number of women and minorities. Not only is this a matter of equity, but it is also necessary to our common good.
- At the elementary school level, instruction in science has almost ceased, being no more in most classrooms than a few minutes a week of reading from textbooks. This deplorable condition came about when the federal government withdrew from the states funds for science specialists to help teachers conduct interesting science activities for children.
- In secondary schools we are seeing a dramatic and disturbing decrease in the quality of science and mathematics teachers. For understandable reasons having to do with income and working conditions, many of the best chemistry, physics, and mathematics teachers are leaving teaching for jobs in industry. Their positions in the classroom are not being filled by other qualified teachers but more often than not by teachers who have little or no training in science and mathematics. Undergraduates are not choosing to prepare for careers in science and mathematics teaching; the schools are not hiring new science and

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mathematics teachers; and the system is simply winding down. The data assembled from recent surveys carried out by the National Science Teachers Association is alarming. Some examples: In 1981, 43 states reported shortages of qualified high school mathematics teachers, 42 states of physics teachers, and 38 of chemistry; among newly appointed teachers in those fields, 50.2 percent were unqualified; the average age of America's science and mathematics teachers is 41, and one in four of the younger faculty among them plan to leave teaching completely; 40 percent of our science teachers have not attended a course or workshop in their subject matter since they began teaching, an average of 16 years, and nearly twice that percentage have not completed a 10-hour course or workshop in over 10 years; and 60 percent of high school science teachers experienced cuts last year in their budgets for supplies and equipment (at a time when labs are already obsolete). The NSF has ceased to provide training opportunities for teachers, while at the same time almost every other major country in the world has copied the NSF summer institute approach. The states cannot afford to provide opportunities previously supported by NSF; school districts have less income than ever before; and the local business and industrial communities do not have a surplus to invest in teacher training and in-service programs. Teaching salaries have so badly deteriorated in this country that teachers themselves cannot afford to go to the universities during the summer, and universities cannot afford to offer free instruction.

Our undergraduate institutions not only initially prepare scientists and engineers but they also educate national leaders, politicians, business people, lawyers, and journalists--in short, the people who make the day-to-day decisions that determine where we will go as a nation. Clearly, these people need to be adequately prepared to operate effectively in a world dominated by science and technology, and yet the task of developing new courses, of outfitting laboratories, and of producing current learning materials appropriate to these students is beyond the resources of the individual colleges and universities.

In the past quarter of a century, the strength of our colleges

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and universities in the technical fields was in great measure due to the investment of the National Science Foundation in improving undergraduate and graduate science education. With that support gone, the undergraduate institutions can only become weaker and surely will not be able to provide the quality of education demanded for the nation's welfare.

- In graduate education the problem is especially severe with regard to engineering and computer science. This is because, as Allan Bromley, Board Chairman of AAAS, has so forcefully pointed out, as a nation we are eating our scientific and technical seedcorn. Because of the draw of the market, B.S. engineer graduates are going directly into business and industry rather than entering doctoral programs. Our supply of researchers in these fields and of professors who can teach the next generation of engineers and computer scientists is rapidly depleting. Institutions have responded in two ways. Engineering schools and computer science departments are restricting admission even though there is a national shortage. They are also depending more and more on foreign instructors and foreign graduate students in their advanced programs. It is ironic that America, which thinks of itself as the world's leading technological power, must import engineering instructors.
- Even if we had better-prepared teachers in our schools and colleges, we would still be in trouble, for the support system that has enabled teachers to keep pace with the state-of-the-art is disappearing. The schools and colleges have archaic equipment that is in disrepair and they cannot afford to replace it. More and more, instruction in science is "textbookish" and badly out of date, for the schools cannot pay for the supplemental materials that can enliven and update instruction. The withdrawal of federal support for our schools, colleges, and public libraries means that these essential elements of the educational enterprise, so vital to good teaching, will be weakened. It should also be noted that the withdrawal of federal support from science museums and from the production of science television programs such as "3-2-1 Contact" means that still another dimension of the science education system is being undermined.

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The major thrust of my remarks has been to emphasize that we have already identified the problems in science and engineering education and cannot afford to spend another two to three years trying to figure out what is wrong. As a nation we need to get on with the job right now of strengthening our science education enterprise.

Each school in the country and each state must join with the federal government and the concerned private sector in a concerted effort to strengthen science education at every level. For their part, the science and engineering societies of America are marshalling their resources. One week from today many of them are meeting to complete the formation of a Coalition of Scientific Societies for Science Education and to set an action agenda. The American Association for the Advancement of Science, with the support of its 140,000 members and nearly 300 affiliated societies and state academies, has launched a determined science education initiative, as described in the booklet Education in the Sciences: A Developing Crisis, which I am pleased to submit with this testimony. Let me close by quoting a few lines from that document, for they express our view of where, in the final analysis, the authority and energy for dealing with this national crisis resides:

> "And finally and most importantly, we know that what is taught and learned, in school and out, depends ultimately on parents and leaders in local communities. Every effort to achieve excellence in science and mathematics teaching and learning must reach out to gain their interest, their cooperation, and their insistence that science and technology education be the best possible in their own schools."

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Mr. MCCURDY. Thank you, Dr. Rutherford. I appreciate your very enlightening comments and I am sure there will be some good questions raised from the points that you have made.

Our next panelist is Dr. Joseph Lipson who is the group project director of training and education division of WICAT Systems from Orem, Utah.

Dr. Lipson, it is a pleasure to have you in Oklahoma, and we welcome your statement and comments at this time.

STATEMENT OF DR. JOSEPH LIPSON, GROUP PROJECT DIRECTOR OF TRAINING AND EDUCATION DIVISION, WICAT SYSTEMS.

Dr. LIPSON. Thank you, Congressman McCurdy. It's a pleasure and an honor to be here.

We live in one of the most advanced technological societies in the world. Yet we are not providing the majority of our children with even the most rudimentary knowledge and skills necessary to contribute to that world, to manage and understand our society.

My comments are divided into four parts: First, I will offer some internal evidence on the poor condition of precollege science education in the United States; second, I will provide some statistics that compare our science education effort with that of Japan and Russia; third, I will describe the consequences I foresee if we, as a Nation, make an inadequate response to this challenge; and, fourth, I will give my recommendations for action by the Congress and the Federal Government.

Consider the domestic evidence of the crisis in science education:

In a nationwide study, lack of student interest in science was reported as a major problem by 50 percent of teachers.

Less than one-fifth of the States require more than 1 year of science in grades 9 through 12. This is one cause of the following statistics.

Of 1976-77 high school graudates, 45 percent studied 1 year of biology, 17 percent studied 1 year of general science, 16 percent studied 1 year of chemistry, and a mere 9 percent studied 1 year of physics.

Over 70 percent of the elementary school science teachers do not feel well qualified to teach science.

There is a documented and growing shortage of qualified high school math and science teachers. For example, there are only 10,000 physics teachers for 16,000 school districts, and the supply is shrinking rapidly.

In a recent Newsweek article the crisis was noticed by an economist, Lester C. Thurow. He said,

> Math and science education is dissolving as math and science teachers abandon our school system in droves for better-paying industrial jobs. Many high schools now have no qualified math teachers on their staffs.

Since 1950 there have been significant declines in the average scores in science and math on the following national tests: American College Test; the Iowa Test of Educational Development; the National Assessment of Educational Progress; and the Scholastic Aptitude Tests.

At least until a couple of years ago the number of degrees in all fields of science, except medicine, was declining. The results of

weak scientific and technical training are strikingly revealed in armed forces tests: Of 1,574 artillery crew members tested, 86 percent were below the minimum level for combat; of 385 nuclear weapons maintenance specialists tested, 90 percent flunked; of 371 tank turret and artillery repair personnel tested, 98 percent failed; of a random sample of nearly 1,300 M–60 tank crew members, one-fourth did not know where to aim using their battlesights; of 1,633 Army computer programers, 77 percent failed to meet minimum standards.

Turn to international comparisons. I present the first statistic to counter the concern that maybe these comparisons are meaningless because the other nations focus only on their elite students while we attempt to educate everyone. I am going to state the percent of youth graduating from secondary schools.

In Russia, 98 percent of their youth graduate from their 10-year compulsory educational program. In Japan 90 percent graduate from high school. In the United States only 75 percent graduate from high school.

Now, look at the degrees awarded to college graduates in science and engineering. In Japan, 20 percent of the degrees awarded are in engineering. In the United States only 6 percent of the degrees awarded are in engineering. As a result, Japan with half the population produces more engineers each year than the United States, and those engineers are more energetically recruited by industry than engineers in the United States. I interpret this to mean that Japanese industry sees a greater opportunity in an engineering graduate than industry in the United States.

In contrast to the precollege requirements in the United States, every Japenese and Soviet student receives an extensive math and science education.

In an international study of achievement in science by 14-year-olds, Japan ranked first, United States ranked 15th. Japanese 11-year-olds outperformed American 14-year-olds. Japanese 14-year-olds outperformed American 17-year-olds.

In scores on an international math test that was taken in 10 countries, if we compare Japan and the United States, the scores of Japanese 13-year-olds were almost twice the scores of American 13-year-olds. The scores of Japanese seniors who were math students was over twice the scores of U.S. students who were math students. The scores of Japanese seniors who were nonmath students were almost three times the scores of U.S. students who were nonmath students.

Five million Russian high school students take 2 years of calculus. Only 10[illegible] U.S. high school students take 1 year of calculus; 98 percent of Russian students take trigonometry; 11 percent of U.S. students take trigonometry.

Consider requirements in other subjects: Russian students have 5 years of compulsory physics; in the United States, as we saw, only 9 percent take 1 year. Russian students have 4 years of compulsory chemistry; in the United States only 16 percent take 1 year. In biology, Russian students have 4½ years; and in the United States the students have about 1½ years or less. In Russia, students have 10 years of geometry; in the United States, typically, our students

have 1 year of geometry. In Russia, geometry is taught as the basis of the entire intuitive understanding of mathematics.

Consequences: Weaknesses in science and technology education contribute to both economic and military weakness. As we struggle to compensate for educational defects, our entire structure of trained talent is distorted. Bidding for talent in short supply creates stress in our pay scales and interferes with the way young people make career decisions. It is reasonable to predict the following effect for the increasing fraction of our lives that is influenced by science and technology.

Our economic position relative to other advanced nations will continue to decline. Our relative standard of living will fall. This has been happening; and it has been documented.

We will have to relinquish our position as leader and shield of the Western Alliance.

Major and minor technology-related decision will be poorly made.

Serious accidents such as occurred at Three Mile Island and in some cases on military bases or in military situations will be caused by a poor understanding of powerful technological systems.

People in general will be pushed to their technological level of incompetence. We will have a split into a technological elite and a nontechnological lower class. Millions of underqualified people will become uncertain and anxious about their place in society. The quality of life for those who are not a part of the technological elite will become mean as people struggle to survive and get their share of the shrinking economic pie.

The deficiencies of American science education take their toll in many direct and indirect ways. Industrial and military leaders are increasingly concerned about the education they must provide to enable workers and soldiers to manufacture, maintain, and use the advancing wave of high technology process and products.

Lieutenant General Hillsman gives a speech in which he describes how the military is trying to work with the high schools to improve the science education systems. When I heard his talk and wrote a letter to one of his staff members, I said,

> I'm a little uneasy about the military taking over a role that was formerly played by National Science Foundation.

I got back the answer,

> Yes, we are a little uneasy too, but we have no choice. We need scientifically trained people in the military and the only way we can get at the problem is to begin to have a relationship with the schools.

A couple of years ago Ann Landers said that unless we do something about our educational system, we will become a fourth-rate nation without a single shot being fired. The process of decline has been visable for all to see for at least a decade.

What has been the response of this military- and business-oriented administration to a problem that is clear to newspaper columnists? In an orgy of penny wisdom and pound foolishness, it has killed the Science Education Directorate of the National Science Foundation.

It remains to be seem whether we can forge the will to act in time.

My recommendations: If this country is seriously interested in stimulating the economy, increasing productivity, and strengthening the military, it is imperative that we make the necessary investments in education. It will not be easy, for all the reasons that some members of the committee have stated.

Course requirements need bolstering at every level. Federal agencies should work with the States on this issue.

Course content must be continually revised to keep pace with new scientific findings and new understanding of how people learn science. Large-scale curriculum development should be supported by the National Science Foundation.

Significant investment must be made in teacher training to complement curriculum development. Teacher workshops should be partially supported by the National Science Foundation.

The classroom itself must be modernized, capitalizing as much as possible on the new information technologies such as the computer and the videodisc. Industry and the National Science Foundation should support a joint effort along lines that are currently being discussed.

Television and other mass media must be used to inform the public about the nature and limitations of modern science and technology. The public understanding of science program of the National Science Foundation should be expanded.

Let me digress just a second to say that one of the ways to solve a problem when it is as complex as this one is, is to make everybody more aware of it. The mass media have the one characteristic that they help people to reorder their priorities. The mass media heighten the consciousness of people about things that they haven't been thinking about previously. And so the role of the mass media in dealing with this problem should not be neglected.

Research and development in science education is needed to design effective instruction for the majority of students who have difficulty with math and science. The development and research program of the National Science Foundation should be reinstituted.

The States and the thousands of individual school districts cannot be relied upon to solve this problem. Although there is much that only they can do, they do not have the resources or the economic leverage needed to solve the problem alone. Education today has such clear national implications that national leadership and national programs are called for.

In prior testimony before this Committee, Professor J. C. R. Licklider of MIT suggested that, to capitalize on the new information technologies in education, we would need to invest $1 billion a year in development.

With the present budget situation, it seems the height of foolishness to propose such a figure. Yet, we have a $4 trillion a year economy that rests on the quality of our educational system. Education is approximately a $200 billion a year industry that desperately needs overhaul.

Educational research and development is like a critical bearing that supports a massive machine. The bearing is crumbling. If it crumbles, our entire society is in danger. I propose that $1 billion a year—one-half of 1 percent of our education and training budget—

is not an excessive investment when the entire future of our country depends upon it.

Thank you.

[The prepared statement of Dr. Lipson follows:]

STATEMENT OF DR. JOSEPH LIPSON

Chairman Walgren, Congressman McCurdy, Members of the House Subcommittee on Science, Research, and Technology.

I am pleased and honored to be here to testify about the crisis in science education that faces our nation. I will keep my points brief and, I hope, sharp in order to fit within the ten minutes I have. If your concern is aroused, I have supplied several supporting documents to Ms. Suzanne Leonard.

My work in this area has been part of a joint effort over the last two years with Professor Kathleen Fisher of the University of California at Davis and she has given me permission to use passages from articles we have written.

We live in one of the most advanced technological societies in the world. Yet we are not providing the majority of our children with even the most rudimentary knowledge and skills necessary to contribute to, manage, and understand that society.

My comments are divided into four parts:

- First, some internal evidence on the poor condition of pre-college science education in the U. S.
- Second, statistics that compare our science education effort with that of Japan and Russia.
- Third, the consequences I foresee if we, as a nation, make an inadequate response.
- Fourth, my recommendations for action by the Congress and the Federal Government.

Internal Evidence of the Crisis in Science Education.

- In a nationwide study, lack of student interest in science was reported as a major problem by 50% of teachers.
- More than half of students surveyed replied that their science courses were too difficult. Yet three fourths felt that science would eventually be important to them.
- Less than one-fifth of the states require more than one year of science in grades 9-12. This is one cause of the following:

  Of 1976-77 high school graduates —

  45% studied one year of biology,

  17% studied one year of general science,

  16% studied one year of chemistry, and a mere

  9% studied one year of physics.

- Over 70% of elementary school science teachers do not feel well-qualified to teach science.
- There is a documented and growing shortage of qualified high school math and science teachers. For example, there are only 10,000 physics teachers for 16,000 school districts, and the supply is shrinking rapidly.
- "Math and science education is dissolving as math and science teachers abandon our school system in droves for better-paying industrial jobs." (Thurow)
- "Many high schools now have no qualified math teachers on their staffs." (Thurow)

- Since 1950 there have been significant declines in the average scores in science and math on the following national tests:

  American College Test (ACT)

  Iowa Test of Educational Development

  National Assessment of Educational Progress (NAEP)

  Scholastic Aptitude Tests (SAT)

- In 1969 14% of all college science teachers were math and physical science teachers.

  By 1975 only 7% of all college science teachers were math and physical science teachers.

- At least until a couple of years ago, the number of degrees in all fields of science except medicine was declining.

- The results of weak scientific and technical training is strikingly revealed in armed forces tests:

  Of 1,574 artillery crew members tested, 86% were below the minimum level for combat.

  Of 385 nuclear weapons maintenance specialists tested, 90% flunked.

  Of 371 tank turret and artillery repair personnel tested, 98% failed.

  Of a random sample of nearly 1,300 M-60 tank crew members, one-fourth did not know where to aim using their battlesights.

  Of 1,633 Army computer programmers, 77% failed to meet minimum standards.

International Comparisons.

> % of youth graduating from secondary school:

Russia 98%

Japan 90%

U. S. 75%

> Percentages of colleges graduates awarded degrees in Science and Engineering:

	Japan	U. S. A.
Engineering	20%	6%
Science	65%	30%

> As a result, Japan with half the population produces more engineers each year than the U. S.

> In contrast to the the U. S. pre-college picture, every Japanese and Soviet student receives an extensive math and science education.

> In an International Study of Achievement in Science by 14 year olds.

Japan ranked 1st.

U. S. ranked 15th.

Japanese 11 year olds outperformed American 14 year olds.

Japanese 14 year olds outperformed American 17 year olds.

> Scores on International Math Test (10 countries).

	Japan	U. S. A.
13 year olds	31.2	17.8
Seniors (math students)	31.4	13.8
Seniors (non-math)	25.3	8.3

> Calculus. 5 million Russian high school students take 2 years of calculus. Only 105,000 U. S. high school students take one year of calculus.

> Trigonometry. % of high school students taking this subject.

Russia	U. S. A.
98%	11%

> Years of precollege study in various subjects.

Subject	Russia	U. S. A.
Physics	5	1 or less
Chemistry	4	1 or less
Biology	4 1/2	1.5 or less
Geometry	10	1

CONSEQUENCES. Weaknesses in science and technology education contribute to both economic and military weakness. As we struggle to compensate for educational defects our entire structure of trained talent is distorted. Bidding for talent in short supply creates stress in our pay scales and interferes with the way young people make career decisions. It is reasonable to predict the following effects for the increasing fraction of our lives that is influenced by science and technology.

Our economic position relative to other advanced nations will continue to decline. Our relative standard of living will fall.

We will have to relinquish our position as leader and shield of the Western Alliance.

Major and minor technology related decisions will be poorly made.

Serious accidents such as occured at 3 Mile Island will be caused by poor understanding of powerful technological systems.

People will be pushed to their technological level of incompetence because talent is in short supply.

Leaders and managers will not be able to plan adequately because they do not understand the scientific and technological opportunities and limits and because they cannot depend on the quality of workers.

The quality of life for those who are not part of the technological elite will become mean as people struggle to survive and get their share of a shrinking economic pie.

The deficiencies of American science education take their toll in many direct and indirect ways. Industrial and military leaders are increasingly concerned about the education they must provide to enable workers and soldiers to manufacture, maintain, and use the advancing wave of high technology processes and products.

A couple of years ago Ann Landers said that unless we do something about our educational system, we will become a fourth-rate nation without a single shot being fired. The process of decline has been visible for all to see for at least a decade.

What has been the response of this military and business oriented administration to a problem that is clear to newspaper columnists? In an orgy of penny wisdom and pound foolishness, it has killed the Science Education Directorate of the National Science Foundation.

It remains to be seen whether we can forge the will to act in time.

RECOMMENDATIONS. If this country is seriously interested in stimulating the economy, increasing productivity, and strengthening the military, it is imperative that it make the necessary investments in education. It will not be easy.

Course requirements need bolstering at every level. Federal agencies should work with the states on this issue.

Course content must be continually revised to keep pace with new scientific findings and new understanding of how people learn science. Large scale curriculum development should be supported by the National Science Foundation.

Significant investment must be made in teacher training to complement curriculum development. Teacher workshops should be partially supported by the National Science Foundation.

The classroom itself must be modernized, capitalizing as much as possible on the new information technologies such as the computer and the videodisc. Industry and the National Science Foundation should support a joint effort along lines that are currently being discussed.

Television and other mass media must be used to inform the public about the nature and limitations of modern science and technology. The Public Understanding of Science Program of the National Science Foundation should be expanded.

Research and development in science education is needed to design effective instruction for the majority of students who have difficulty with math and science. The Development and Research program of the National Science Foundation should be re-instituted.

The states and the thousands of individual school districts cannot be relied upon to solve this problem. Although there is much that only they can do, they do not have the resources or the economic leverage needed to solve the problem alone. Education today has such clear national implications that national leadership and national programs are called for.

In prior testimony before this committee Prof. J. C. R. Licklider of MIT suggested that, to capitalize on the new information technologies, we would need to invest one billion dollars a year in development. With the present budget situation, it seems the height of foolishness to propose such a figure. Yet, we have a four trillion dollar a year economy that rests on the quality of our educational system. Education is approximately a two hundred billion dollar a year industry that desperately needs overhaul. Educational research and development is like a critical bearing that supports a massive machine. The bearing is crumbling. If it crumbles our entire society is in danger. I propose that one billion dollars a year — one-half of one percent of our education and training budget — is not an excessive investment when the entire future of our country depends upon it.

Mr. McCURDY. Thank you, Mr. Lipson, for your very inspiring comments. Certainly I think you have raised a number of very interesting statistics. I think there will be some questions.

In the interest of time, we will be maintaining the 5-minute rule—that each member will have 5 minutes—because we do have a second panel. I do apologize for the shortness of that time. We got carried away this morning. But it is certainly not because we are ignoring the problem. We have other members that must participate.

I have said from the very beginning, and I concur with your statement, Dr. Lipson, that the mass media does have a very important role. I think the Congress itself has an important role, not only in the development of overall policy and strategy in determining what the role of the Federal Government will be and should be in this area, but also to help communicate to the American public the nature and extent of the problem. That's one of the reasons for

field hearings such as this, to get out of that marble city up there. For some reason they think the whole world is reflected there, while I think that many times it's just the contrary.

I am on the Armed Services Committee, and I was interested particularly in the dual assignment in some of the comments that you had made in regard to the lack of skills in the military. I think we will be seeing a greater emphasis come from that committee in this area.

We are currently debating the GI bill which the Veterans' Committee's discussed also. I think you will be seeing some action from there very soon.

This bill that we have mentioned earlier kind of reminds me, and I always refer to my colleague from Texas for the better wit, but this reminds me of a group of hunters who are going bird hunting. It is always that first bird that is flushed, that is just blasted; it's just destroyed. And I think this bill may perhaps be that first bird in the legislative arena, and there are a lot of hunters out there, and I think that we have to flush a bird. The issue has to be raised, and I think the comments that you have made address this particular problem.

In that relation I would open up to the panel, to any of the members to reply.

This bill, the National Engineering and Science Manpower Act of 1982, attempts to focus Federal attention to developing and coordinating the National Technical Education Policy.

Do you believe this legislation is an effective vehicle for such coordination and implementation? I might also mention that we are talking about a tentative figure or a proposed figure of $50 million, I suppose for 1 billion that Dr. Lispson had mentioned.

What is your personal comment as to the act itself?

Mr. RUTHERFORD. Yes, I have had a chance to read the act, and previously gave some testimony on it. It's a frame-of-reference problem.

Looked at from one point of view, it's totally inadequate for some of the reasons that Dr. Lipson mentioned, that is to say, we are not dealing with a $50 million problem. We are dealing with a much more complex, larger scaled one than that.

On the other hand, one has to get started, and a great virtue of the bill is that through it Congress is saying to the Nation, "Look, this is a problem."

The quality and supply of our scientific and technical manpower is not a matter simply to be discharged without investigation. We have to move on it.

It's clear that various parts of Government have a responsibility and are even doing some things, but there is very little coordination. There's little direction. A bill such as this, provided with some funds, could begin to put some coherence, logic and direction into it, and ask questions such as: What should the Commerce Department be doing, and Energy, and Defense, and NSF?

I question some of the details, but the major thrust is appropriate for the times.

Mr. MCCURDY. Of course, it is a very broad bill and very broadly stated.

We hear—and I know my colleagues have mentioned this earlier—there has been, I think, tremendous industry support in advanced research. And of course, in addressing some of the problems at the graduate levels of engineering. Certainly supply and demand does have a critical role. My question perhaps relates more to the elasticity of the supply and demand and how much time is involved. How much time it takes to get the supply up to meet the demand. I think we have a tremendous demand here, but we hear much more about returning control back to the States and trying to get business interested and industry interested in this problem

What, in your perspective and background, what have you seen as the role of industry and how can they help? Do you see them coming forward to assist in the addressing of this critical problem?

Mr. LIPSON. I am with a company, WICAT, that produces courses for training in industry using advanced technologies, industries like IBM and AT&T.

The problem is that companies are under the gun in trying to train their own people. As new equipment comes out more and more rapidly in an increasingly competitive environment—for example, you are working on the bill that will regulate how AT&T and IBM do business—they have thousands and thousands of workers who need to be trained specifically on the equipment that they are generating.

They, in fact, are putting a lot of their resources into that process. By doing that they indirectly will help those workers, and also help to develop the techniques of training which may, in some way help the schools.

As far as industry providing direct help for the schools, I have seen very little. We have the example of the Apple Computer Corp. saying: "Pass the right bill and we will put computers in every school in the country if we can figure out how to do that."

They got newspaper publicity all over the country and started people talking. However, I have not seen any impressive direct leadership and help. I certainly wouldn't discourage the idea of help from industry. The resources are there, if they choose to allocate them in that way and if they can justify the action to their stockholders.

Mr. RUTHERFORD. My experience in talking, particularly in the last 6 months, with many representatives of industry drew very diverse kinds of responses. Most of the company officials I have talked with have felt very comfortable about doing more to support education at the graduate level, and a little bit at the undergraduate level. They know how to provide equipment for research and training of students at the universities and engineering colleges.

What they feel very uncomfortable about is breaking the barrier and moving into the public school system as patrons. I mean, what is their role? And I think most of them feel that they don't want to be in a position of influence on State and local education.

On the other hand, some companies such as Gulf Petroleum, which you will hear about later from Mr. Crimmins, have been very forward looking in supporting some of the more daring kinds of attempts to improve education; that is, more daring than Government is usually allowed to get away with. The State and local governments have to be conservative, so a few companies are be-

ginning to underwrite development of some new ideas and programs. After visiting some companies and seeing how industry uses modern technologies and invests in the development of software and support systems, it is rather discouraging to go into an American school and see that this technological Nation hasn't found out how to provide even approximately the same level of training in technologies to the teachers in the schools.

I don't know how to move that across, but industry isn't likely to do it on its own.

Mr. McCURDY. Thank you, Dr. Rutherford.

In the interest of time, the Chairman, too, will adhere to the 5 minutes. At this time I will turn it over to Mr. Sensenbrenner.

Mr. SENSENBRENER. Thank you very much, Mr. Chairman.

Because of the time constraints that we have, I think I will just make a couple of comments rather than asking a question. And if any of you really violently disagree, please speak up.

I think that there are really two points that have got to be made. First of all, in terms of comparing the American school system with the school system of foreign countries, including that of Japan and the Soviet Union, we have to recognize that there really is, in America, a maximum amount of students' freedom and student choice, both in the high school level, as well as at the undergraduate and graduate level. Students take those courses that really interest them. That kind of intellectual freedom, I think, has resulted in our economy being extremely more creative than the economies that are populated by products of school systems where there is a high degree of mandated curriculum, such as 10 years of geometry in the Soviet Union.

Now, I don't think we want to get to a point where we say, "Either you take these courses, or you don't go to school".

I also look at the fact that with our creative education system and the innovation that it has spawned, many of the products that the Japanese aggresively market in the United States were originally invented here and pirated by the Japanese. They have just done a better job of producing and marketing them. So I don't think the problem is with the education system. I think the problem is in other areas of our economy.

Second, with respect to how we get at the problem of providing things like better teacher certification standards, changes in State-mandated curriculum laws, as well as equalizing salaries so that fewer teachers decide to leave the teaching profession to go to better paying jobs in private industry, I would submit that there is a marvelous organization called the Education Commission of the States that is in a far better situation than the National Science Foundation or the U.S. Congress to bring improvements about.

I am a graduate of the Wisconsin Senate Education Committee, and much of the testimony that we heard today I have heard before, in a little different context in the State capitol building of Madison. The problem is there, and the problem is real. But it seems to me that ECF-sponsored programs, both in terms of statutory changes as well as in terms of classroom educational technique changes, are perhaps a far more effective way of going about it than having the Federal Government come up with an advisory

program that is recommended to States and to local school districts.

It seems to me that a lot of people are proposing a Federal response to the problem, that will just put several more layers of filter on the problem, which means that less of the actual "meat" gets down to those who want to help.

Mr. McCURDY. Thank you, Mr. Sensenbrenner.

Gentlemen, any comment or statement? If not, I will turn to Mr. Hall.

Mr. HALL. Thank you, Mr. Chairman. I did not have any comment on that.

I didn't know what he said either. [Laughter.]

I don't really mean that disparagingly. I just was reading and not listening, but I will reread his testimony because I have high regard for the Congressman and don't disagree with him on the practicality of setting aside the amount of money. And I think when we really get into it and legislate it as we are doing here today—and by the way, I think once again, from the standpoint of levity, there are two things people ought to all see, and that's a legislature legislating and a farmer making sausage, because they are very much alike. [Laughter.]

The ingredient has to be palatable and as the Congressman said, it has to be palatable to the American people before they will approve the expenditure that we are looking for.

But of the $50 million, I think we need to point out that won't be new money. It will come from redirecting some of the money that is directed, as Dr. Joe has indicated, maybe in the wrong direction.

Some of it can come from the $8 billion that is nonstudent aid that might be still needed, but needs to be redirected. It could come from the $216 billion defense budget that also alludes to the training of scientists and the pursuit of excellence in that field.

I think that's what you're saying, and what you're telling us.

I know one thing, I visited Goddard as a member of the National Subcommittee, and I found out that they couldn't advertise, for example. They are precluded by law from advertising the fruits of their shuttle mission. They can't push or pump themselves. I think that's a mistake, and certainly I think we need to—I have a question I want to ask. It has no relation to the testimony you have given directly, and that is, what is your opinion on dismantling the Department of Education? And if you dismantle it, where should it go?

Mr. RUTHERFORD. I used to work there. That was the last administration.

At the time the Department was being formulated, I was not an enthusiast for it. There are arguments on both sides that make a lot of sense.

I particularly cared to comment about the transfer of programs from the NSF to the new Department and how that might work out.

Nevertheless, the Department came into being. It seems to me that with Government, these categories and things matter less than the opportunity they provide for getting work done.

Where we missed, have been missing this last year and a half on exploiting the Department of Education, is that we are hung up on

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the question of whether or not it exist, rather than the question of, since it's there, how can we use the opportunity of a new department to consider from the ground floor up what we ought to do at this level to be an effective partner with the States and the localities and industries, to help raise the quality of education?

We would ask, is it a department that could deal with questions of what it might do to help in its programs of equity to get more minorities and women interested in scientific and technical fields? I think to dismantle the Department now would be a signal. The programs will go on. That will be decided by Congress. They will be scattered around and they will violate the very thing that many of the same people were saying 2 years ago, "We need some organization, we are wasting money; we have overlap. Let's make sense out of it."

I think it would be a retreat and a signal to the Nation that education doesn't sit at the head table.

Transportation, business? Look who's on the Cabinet. Such august things as Transportation. Transportation is important, Agriculture is important, Energy is important, but to kick Education out would be exactly the wrong symbol when the whole system is now in a very weakened condition and needs to strengthen itself.

Mr. MCCURDY. Yes, Dr. Lipson.

Dr. LIPSON. I think there is a problem with education in general. You are to be commended for taking the effort and having the will to consider the education problem. Because education is a low status industry in this country. It is a low status problem. So that when Members of Congress pay attention to education, you help a little. You also run some risk to yourselves, and I think that is very unusual.

The point that I'm trying to get to is that quite often people in the education part of the Federal bureaucracy are also of low status within the bureaucracy. When they say something as experts, they're simply ignored.

Almost anyone in the Office of Management and Budget can tell someone connected with education, "I don't believe you, give me more proof," and get away with it in a way that they could not with almost any other agency.

So that the problem, as I see it, is how to get people into the education establishment of the Federal Government that have the status to be trusted to run the education affairs of the Federal Government.

Mr. HALL. Well, I think we are all in agreement here that we do have a science education crisis. Are we in agreement as to its origin or the cause of it? Is it the States? Is it National Science Foundation? Is it the Congress?

Mr. RUTHERFORD. All of the above.

SPEAKER FROM AUDIENCE. Society.

Dr. LIPSON. As the lady said, it's also society. The United States tends and has tended to be practical and anti-intellectual at a time when organized intellectual intelligence is suddenly moving center stage in the world, in practical, economic and military terms. For a while the scientists that helped the country win World War II had a tremendous amount of clout in Washington. And so when Sput-

nik went up, those scientists could go to the Federal Government and say, "Look, this is what needs to be done."

Now, I think that some of the things that they said needed to be done did not fully take into account the complexity of the educational system that Dr. Rutherford alluded to.

As a result, some of the effects of that tremendous push after Sputnik during the 1960's were counterintuitive. The results were the reverse of what the Government and the scientists hoped for.

That credibility of the scientific community is gone. They no longer have that easy access to influence and power in Washington. As a result, we have to move into the political discussion with the Nation as a whole. We have to say, "Can you appreciate, can you, the American people, appreciate what the consequences will be to our Nation unless we get on the stick in this matter?"

Mr. HALL. Now, would you agree, Dr. Lipson, that while I accept the fact that Congress has been lax and so has society, as the lady very adequately pointed out, would you also agree that perhaps the scientific community has been a little bit hesitant to offer their leadership and their complaints and their very learned voice as to the needs that has caused the atrophy and the wasting away?

You know, I have heard it said, an old storekeeper's philosophy is that he ignored the impossible and cooperated with the inevitable. Is that what your community has done? And is there something that not just the Congress and the people should do, but those that have the knowledge and the pursuit and the background, and the people whose voices should be listened to should be a little more foreceful.

Dr. LIPSON. Yes. I think it is worse than you state. I think that in pursuing self-interest at the expense of group interest; in pursuing short-term interest at the expense of long-term interest, the scientific community has not acted well in this matter.

Whenever there was a choice in the National Science Foundation between funding basic research and supporting education they sliced education.

At one time the education fraction of the National Science Foundation was about 50 percent. It has been salamied until now it is virtually no longer in existence.

I think that the scientific community has long felt that as long as they had a good supply of bright graduate students all was right with the world. And this was simply, to me, a shortsighted and self-interested viewpoint.

Mr. RUTHERFORD. May I make one comment for the National Science Foundation, for the research community? Since 1968 we've heard the question, "Why are we in such trouble after having had all of those NSF programs?" The fact of the matter is, the investment was always tiny, but starting in 1968–69 it came under attack, it zoomed down, and for over a decade now, those programs have had almost no support. So, in fact, you can see that a lot of the problem has to do with taking off Foundation support, and the scientific community permitted that to happen. But I think that is in the process of turnign around. At the last two meetings of the AAAS on the Federal R&D budget, the scientists, meeting there to talk about the research budget, spontaneously brought up over and

over again the question of science education. We now have to look to that process as our really long-term investment in research.

Mr. McCURDY. Thank you.

In the interest of time now, Mr. Weber?

Mr. WEBER. Thank you, Mr. Chairman.

As we came here this morning we all said, "We understand there is a problem." Everybody agreed with that.

What I was looking for, frankly, from the panel was some fairly specific guidance in terms of exactly what the Federal Government's contribution to the problem has been, and some more specific guidance in terms of precisely what the Federal Government can do to deal with that.

And I don't mean this critically of the panel, but I think they have highlighted the problem again very, very well for us. Much of the testimony we have heard has provided a great deal of explanation of many many of the components of the problems and the complexity of it. I would like to ask the panel members again to try and respond; and I am not quite sure how to focus it. What exactly is it the Federal Government ought to do?

Perhaps, Dr. Rutherford, I can direct it to you because I did notice that you mentioned that your community has been concerned for at least 10 years about this problem, and it is not something that just came on the scene in the last couple of years.

What is it that you have been urging on the Federal Government for 10 years and that they have not done, that specifically we ought to do?

Mr. RUTHERFORD. Without trying to defend the claims, let me suggest just four or five things I think the Federal Government ought to do, knows how to do, and can be doing while the Commission is working with some of the tougher problems. It costs a little bit of money.

No. 1, we have been backing down on support of young students. Congress should require the National Science Foundation to invest some few millions per year with the continued identification of summer work for young people at the universities.

No. 2, the Congress of the United States, should require the National Science Foundation to once again institute summer institutes for high school and junior high school teacher. I would give these priority: 6 to 8 weeks of intensive summer work in their fields, providing tuition, books and stipend to make it possible for them to do it. We are talking of $2 million.

No. 3, it should require the NSF to reconstitute the Chautauqua program, which cost only $2 million, and which provided 4-day workshops for undergraduate teachers of science and mathematics in all our colleges, especially the small colleges, throughout the country. It's a popular program, and we know how to do it and how to keep it cost effective.

The next item I would add is that the Federal Government through the Department of Education, and perhaps through NSF—the agency doesn't matter much—should insist upon the continued funding of certain kinds of television programing, such as 3-2-1 Contact, and other programs that can't be done locally to reach out and get young people interested in science and technology.

Finally, the Federal Government, which does invest in the support of graduate students, but does it in a helter-skelter way in lots of different agencies, ought to reexamine that program entirely to take account of the marketplace and of the need to continue to attract high talent. In my judgment, the NSF science fellowship graduates do not do either of those very well any more, so that needs a whole new look.

Those are specifics.

Mr. WEBER. Thank you. Those are very helpful suggestions.

I want to ask you a tough question, and I realize that you may not want to answer it, but there are certain questions we've got to answer. This committee has dealt with the National Science Foundation budget in a very frustrating atmosphere. We have declining resources. How do we spend it best? How do we target it? And I'm not trying to flush this pheasant out again, but the things that you just talked about are going to cost some money, and I recognize that— and I don't think any of us would argue there shouldn't be some Federal investment in this problem.

I am going to ask you, are those things more important than the $50 million that we would spend on this bill? You said you are familiar with the bill, and I'm asking you to make the kind of judgment that we, as members of the committee, are going to have to make. We can't fund everything.

Mr. RUTHERFORD. No, but you have other choices. This bill attempts to give one narrow aspect of the problem of the manpower situation. I have been talking about the broader problem of the scientific education of the total society.

Before I answer your question, let me give you an answer that maybe you don't want. If we appropriate zero sum, the money has to come from money that is already there as opposed to appropriating new funds. Then, the scientific research budget is going to have to suffer a little bit. In basic research, if we put off some of the discoveries, say, in astronomy and physics and chemistry—and I don't want to hurt anybody's special field—suppose it takes another 2 years or another 5 years, and suppose something gets discovered in Europe or Japan? We are talking about basic knowledge and we are all in it together. We are not trying to race against the clock tomorrow.

Applied science is different. I don't say it comes down, to shaving some of the resources for the short-term scientific research and investing in education, which is long term.

Mr. WEBER. Let me interrupt. That was precisely the amendment that the National Science Foundation authorization that I authored in committee; I am very glad to hear you say that, and I am anxious for you to continue.

Mr. RUTHERFORD. I shouldn't, unless you want to share your salary. I don't want to do your work for you. [Laughter.]

The trade-off again, for this bill is tough because there are apples and oranges. This bill really deals with the deep need to have coordination and coherence put into this system. I like the part of the bill that proposes gathering information, making sense out of it, trying to get the agencies to work together and to plot out the future. That needs doing, and this bill, I think, would do it.

Mr. WEBER. Thank you very much. I appreciate that.

Dr. LIPSON. Can I make a couple of comments?

First of all, you have to be aware of where the money comes from. I think you have to be creative. For example, one of the things that I recommend is a much new larger investment in the use of the mass media. You make the entire Nation aware of both the problem and the nature of science and the limitations of science. People in this country often treat science the way they do astrology: they hope that good things will come from the witch doctor. And somehow, if we are going to move into the next century and compete in this world, we are going to have to get away from that.

The mass media, even when I was in a different division and it was somebody else's budget, if I had to spend the NSF money in one area, I would spend it on the mass media. But quite often it was extremely difficult to do that because of multiple constraints and the sensitivities were quite large.

But the point I wanted to get to is about funding. In Great Britain every time someone buys a television set they pay a tax that goes to fund the BBC. And as a result we keep buying, in our free enterprise system, the products of the BBC.

We now have information technology which is growing at a tremendous rate. If there were a tiny tax on every bit of information that flows from the technological world—and I have asked many industry leaders in computer companies and telecommunication companies if there was a tiny tax that would be invisible to everybody using the system, it would put funds into a kitty that could be used for the kind of development that I am talking about. And I would propose that you consider it.

The second thing is that, in other countries for example, in Russia which has its own problems with its rigid bureaucratic authoritarian system, but they get the best talent in the country, the best scientists to work on the development of new materials for the precollege system.

It is very difficult in this country to do that. As soon as you do that you tend to begin to lose status with your colleagues. So, I do not think we have problems. But I would propose that one of the things that the Federal Government did, and that I can't see any other way to do, is to continue this development of new course materials.

Science is progressing at a tremendous rate. Unless the courses reflect that knowledge, our students are going to be behind the eight ball no matter how well educated they are.

Mr. MCCURDY. Thank you, Doctor. And thank you, Mr. Weber.

We will break at this point. I would like to announce that we will probably take no more than a 5-minute break. We will have a second panel that is here and we will have them move up.

I would like to make one statement though. We would like to be able to submit some questions to the panelists, that perhaps they could submit some answers for the record, which would be very helpful for us.

Again, keeping in mind that we are dealing with the establishment of some natioal priorities, and regardless of what area we are taking the money out of, that the interest is what are the priorities

of education and how do we attack this critical problem that we are facing today.

I want to thank you for making the effort to come to Oklahoma and provide not only testimony to this subcommittee and the panel, and eventually the committee and the Congress itself, but to the participants of this seminar this afternoon, thank you. [Applause.]

[Thereupon, a brief recess was had.]

Mr. McCURDY. I would like to get started because we are running short on time. As Chairman, I will tell you that we will finish at 12 o'clock. We have a number of witnesses yet to make statements. I again want to welcome them to the subcommittee hearing and I would like to request that they keep their comments to roughly 5 minutes. I apologize for that in running over, but we are faced with some other constraints, not only budget constraints but time constraits.

I also apologize for the seating arrangements. It is difficult to put you up on the stage all at one time. I hope that you will indulge with us. Again, I would like to stress to the audience and again the panel that this portion of the hearing is dealing with Oklahoma's curriculum problems and teacher shortage. I think you were sitting through the first hearing and that you saw a number of questions raised about local governments and school boards, State and local concerns, and perhaps you might address that in your statements. If not then, then perhaps during the questions after it.

So at this time, going in order as listed, I will start with Mr. Gene Smith, the science coordinator for the Oklahoma State Department of Education. Welcome, Mr. Smith.

STATEMENT OF EUGENE V. SMITH, SCIENCE SPECIALIST, OKLAHOMA STATE DEPARTMENT OF EDUCATION

Mr. SMITH. Thank you.

One of the primary concerns of the State Department of Education is the declining rate of qualified students who are currently enrolled in approved teacher education programs. This is perhaps most apparent in the fields of science and math.

For several years we had an oversupply of teacher applicants for every vacancy. As a result we lost many prospective excellent teachers when they were forced to seek employment in areas other than teaching in order to survive.

As our economy improved, industry, with offers of higher salaries and fringe benefits has attracted more graduate students each year, particularly those students who are proficient in math and/or science. This has results in a critical shortage of teachers in our schools.

The State Department of Education recently conducted a survey of the 457 school districts within our state. As of May 3, 1982, 339 replies have been received, which is approximately 74 percent of the total number. This survey requested information regarding the number of teachers within the district having a teaching assignment in science, the type of certificate held by these teachers, that is, standard, provisional or temporary, as well as information concerning the years of experience and the number of anticipated va-

cancies at the end of this school term. We also requested comments regarding possible solutions to the problem of the shortage of teachers in science.

Analysis of the data received revealed that school size is a factor in teacher turnover. The smaller school districts appear to have about three times as many vacancies each year as the larger school districts in proportion to the total number of teachers employed.

About 90 percent of the teachers in grades 9–12 who are teaching science one-half time or more hold standard certificates. However, only 52 percent of the teachers at this same level, who teach science less than one-half time have a standard certificate, and a larger majority of the remaining 48 percent have a standard certificate in another teaching field with a minor approval credential in science.

In looking at grades 7 and 8, 52 percent of those teaching science one-half time or more have a standard certificate in science and almost half of the remaining 48 percent have an elementary certificate which requires only 12 credit hours of science.

Further analysis of the data indicates 30 percent of all science teachers have 4 years or less teaching experience and a large number of those having taught 10 years or more will soon be reaching retirement age.

We anticipate that vacancies in the science area for the school year 1982–83 will be at least 250. One superintendent stated that he currently has about 50 applications on file, however, none are certified to teach either math or science.

I want to stress at this point that this problem is not unique to the schools in Oklahoma. National surveys indicate shortages of qualified teachers in all areas of science, but particularly in the fields of secondary physics, chemistry, earth, and physical science.

The superintendents replying to the State department of education questionnaire made many pertinent comments. Most were in agreement that the current pay schedule for teachers cannot begin to compete with the salaries available in private industry. Some recent graduates have starting salaries two to three times that of a beginning teacher. It is therefore obvious that we must take immediate action to improve the financial situation of our teachers. Due to inflation, our young people who would like to go into the teaching field realize the impracticality of a beginning salary of $11,600.

Other recommendations included offering summer sessions funded by the National Science Foundation, in order to upgrade the quality of teachers. Federal as well as State funds could be earmarked for this purpose.

Total enrollment in our schools has declined 29,038 students in the past 9 years. It is anticipated that this trend will continue for the next few years. However, current data that teacher availability is decreasing more rapidly than student enrollment.

Long-range consequences of continued critical shortages on the total education system can be extremely serious. Many science courses are being taught by less qualified teachers and this threatens the quality of instruction in these areas. Many schools will be forced to drop some science courses currently offered because of staff shortages. Others will attempt to resolve this problem by increasing class size to accommodate the students enrolled.

Students have a right to learn how to think scientifically and to solve problems through the active use of science processes. They should have ample opportunities to engage in scientific work through laboratory or other hands-on activities. These concrete experiences are necessary for prime results at the elementary as well as the advanced levels of learning. As class size is increased it automatically becomes teacher oriented rather than student oriented with demonstrations in lieu of laboratory experiments.

One year of science is mandated in the State of Oklahoma for the high schools.

At this time 153 schools in our State require 2 years of science in grades 9–12. The State Department of Education would like to recommend this be mandatory for all schools. However, due to the shortage of qualified teachers in science, it is not practical at this time.

In conclusion, the major purpose of science education in our schools should be to lay the foundation for students to take more science. Science courses should prepare students to utilize science for improving their own lives and coping with an increasingly technological world. To accomplish this we must continue to train and obtain quality science teachers.

And I would like to add also from information that we got from the State department of education data center on the ATC scores, the scores show a gain in science during the past 10 years. This is compared with the national. We are 0.6 of a point below national average now. The national average may have dropped, so it really is not all conclusive.

And also that the percentage of students enrolled in science has not declined in the past 7 years.

Thank you.

[The prepared statement of Mr. Smith follows:]

TESTIMONY

by

Eugene V. Smith
Science Specialist
Oklahoma State Department of Education

"Oklahoma's Curriculum Problems and Teacher Shortages"

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QUESTIONNAIRE - SCIENCE

2. How many teachers in grades 9 - 12 have a teaching assignment of one-half time or more in science? 954

3. Of those listed in Item 2, how many hold a

   (a) Standard Certificate in science? 850

   (b) Provisional Certificate in science? 59

   (c) Temporary Certificate in science? 28

4. How many teachers in grades 9 - 12 have a teaching assignment of less than one-half time in science? 197

5. Of those listed in Item 4, how many hold a

   (a) Standard Certificate in science? 103

   (b) Provisional Certificate in science? 10

   (c) Temporary Certificate in science? 10

   (d) Certificate in another subject and a minor approval credential in science? 75

6. How many teachers who teach science in grades 7 - 8 one-half time or more hold a

   (a) Standard Certificate in science? 424

   (b) Provisional Certificate in science? 58

   (c) Temporary Certificate in science? 142

   (d) Elementary Certificate with 12 hours of science? 178

7. For those on your staff who hold a standard or provisional certificate in science, indicate the number having the following years of experience, including this school year:

   1 year 108

   2 years 94

   3 years 93

   4 years 90

   5 years 355

   10 years 566

8. How many science teachers have left your staff since January 1980 to take non-teaching jobs? 172

9. How many vacancies did you have in science at the end of the 1980-81 school year? 257

10. How many of these vacancies were you able to fill with a teacher holding a standard or provisional certificate in science? 205

11. How many vacancies in science do you anticipate for the 1982-83 school year? 195

12. Comments (possible solutions, quality of teachers, etc.; use the back of the page if needed):

    5/3/82 339 returns of 457 districts (74%)

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COURSE NO.	COURSE NAME	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
0302	Science 8	29,512	38,791	35,679	34,317	34,415	33,124	34,796	31,051	30,894	29,308
0303	General Science	23,406	26,037	22,561	25,423	25,497	24,985	24,851	24,362	24,734	21,663
0304	Biology I	31,136	35,361	34,176	32,225	31,950	32,623	31,910	30,998	29,286	27,531
0305	Biology II	2,763	2,665	1,984	2,663	2,687	2,872	3,045	2,221	3,158	2,728
0306	Physics I	2,497	2,771	2,215	2,387	2,257	2,607	2,377	2,368	2,385	2,263
0307	Physics II	85	190	170	104	17	46	119	87	64	52
0308	Chemistry I	8,737	8,195	7,840	7,893	8,978	8,210	8,535	7,924	8,245	7,899
0309	Chemistry II	577	722	1,301	685	612	659	800	698	745	685
0310	Geology I	565	560	460	300	528	476	743	599	583	416
0311	Geology II	0	0	19	21	42	18	37	20	0	0
0313	Earth Science	6,597	8,043	7,095	8,796	8,646	10,447	9,242	7,686	7,498	8,199
0314	Physical Science	12,598	11,164	11,151	12,064	12,383	13,341	12,449	13,685	12,731	12,180
0315	Life Science	4,387	4,885	5,359	4,008	3,847	4,507	3,992	4,768	3,595	4,586
0316	Botany	420	619	408	586	572	661	749	655	794	808
0317	Zoology	276	502	392	785	630	626	598	845	685	746
0318	Aeronautics	520	374	668	505	477	585	566	619	322	420
0319	Physiology	2,420	2,995	1,909	2,233	2,127	2,223	2,364	2,270	2,347	2,178
0320	Photography	78	164	150	107	132	224	206	248	410	299
0321		0	20	0	0	0	28	0	0	0	0
0322		0	455	0	0	0	0	0	0	0	0
0323	Science Seminar	19	47	42	13	27	20	30	98	105	86
0324	Electronics I	92	138	83	47	22	127	140	82	82	47
0325	Electronics II	0	24	31	9	0	5	12	0	13	0
0327	Space Science	0	136	33	80	119	105	68	0	0	0
0328	BSCS Biology	2,572	1,418	455	309	464	557	264	608	168	263
0329	Survey Tech	37	0	0	7	0	0	0	0	18	18
0330	Science 6	0	6,043	5,967	5,778	6,582	7,721	7,870	7,608	8,642	9,404
0331	Engineering Science	0	65	66	58	83	47	57	0	24	97
0332	Other Physical Science	0	1,330	1,142	2,201	2,677	2,042	2,194	874	634	808
0333	Other Biological Sci	0	374	622	578	782	866	792	1,227	1,049	1,274
0334	Other Earth Science	0	552	684	439	599	608	625	593	417	251
0335		0	70	0	0	0	0	0	0	0	0
0366		0	5	0	0	0	0	0	0	0	0
0326	Electronics III	0	0	0	0	0	24	0	0	0	0
Total Students 7-12			187,208	168,432	170,519	173,870	176,336	174,639	165,236	165,720	159,923
% of students enrolled in science					58.43%	59.27%	60.24%	60.70%	85.94%	60.97%	60.24%

TOTAL ENROLLMENT FOR OKLAHOMA SCHOOLS

	7th	8th	9th	10th	11th	12th	Total
1974-75	51,946	51,463	51,924	50,126	45,207	41,166	291,832
1975-76	51,422	51,458	53,993	50,643	45,804	40,025	293,345
1976-77	49,700	50,790	53,113	50,797	46,521	41,781	292,702
1977-78	46,333	49,658	51,483	51,008	47,030	42,173	287,685
1978-79	43,373	46,320	50,286	50,160	47,433	42,760	280,332
1979-80	43,346	43,076	47,076	48,763	46,704	42,840	271,805
1980-81	43,590	43,468	44,677	45,658	45,744	42,355	265,492
1981-82	46,132	43,781	44,901	43,588	42,627	41,765	262,794

SUPERINTENDENTS COMMENTS ON POSSIBLE SOLUTIONS, QUALITY OF TEACHERS, ETC.
(#12 of Science Questionnaire)

Higher Salaries - can't compete with industrial job salaries.

Our beginning teachers have no knowledge of classroom management. I think this should be taught in college. The only managers we get are P.E. majors.

For past several years have had very few science applicants. Would very probably experience much difficulty in trying to fill a science position.

Pay them like a vocational teacher.

Kill 1706.

When you have an opening you do not have very many qualified applicants. Three out of four of our science teachers in 8th and 9th grade are coaches, P.E. is their Major field with science as their Minor. Real hard to locate physics and chem teachers with many hrs.

Physics teacher is a math teacher. Although the Jr. High teachers have Standard Certificates they have minor degree in Science - 18 hours or more. H.S. teacher has Standard Certificate but just has minimum in chemistry.

This school system has had rather good success in filling science vacancies except where coaching vacancies are a factor.

Superintendent is only teacher with standard math and science. We conducted a three state search and was unable to employ a well qualified teacher of science.

Science teachers are the most difficult to find. The quality science teacher always seems below the quality of teachers in other fields.

From the number of applicants in science, I know that there are not enough good ones available for all schools to have quality staff.

Return to a program similar to the NDEA where the National Science Foundation funds summer math and science institutes.

I don't believe it will do any significant good to encourage colleges and universities to turn out more science teachers. Traditionally, they have turned a deaf ear to our requirements and I fully expect they will continue to do so.

Continue raising pay schedule.

Science teachers become mud engineers and other related fields in oil production starting at $3000.00, cars and expenses and area education cannot compete with now. Those that I was able to obtain in math and science are paid more than regular classroom teachers. I do not know how long that we will be able to continue as of now.

If you are not able to compete you get a less productive teacher. I believe it would take $24,000 or above to attract and hold the teacher all of us want.

Get those salaries up to compete with private business!

Science and Math teachers are not the only teacher shortage. All teachers are becoming scarce. Teachers can go into other jobs and make $10,000.00 or more starting than they can make in teaching. How many families can live on a starting teachers salary of $11,600.00? Teachers are going to industry and starting out between $20,000.00 and $30,000.00. Teacher salaries are going to need to be increased to entice students to go into education. I hope, for the benefit of the young people of Oklahoma, that we will be able to find qualified teachers to teach in the future. Oklahoma has a quality educational program.

Repeal 1706. Salaries competitive with industry.

Science teachers are non-existant in applicant pool.

We have been fortunate in that our high school science teacher has been in our school system for 24 years. Consequently, we have not been in a position to seek qualified science teachers for the past six years, since our Junior High science teacher has been with us for six years.

Make teaching salaries equal to salaries outside of teaching fields.

We are losing our Science teacher this year to industry. Most science and math teachers can make about two times the teaching salary outside.

There is a shortage of certificated science, math and music teachers based on my hiring experiences over the last two years. Other areas (i.e. elementary teachers) have an abundance of certified people but a shortage of quality people.

Teachers salaries must be competitive and job conditions must be better.

Scholarships for prospective science or math teachers who qualify. Guarantee five years or so of teaching in return for scholarship. Build in a salary plus for scarce fields including math and science, financed by State.

Pay more salary. To receive a degree to teach science requires lots of extra lab time.

I find math and science teachers are impossible to find in a small school.

We have an individual in the community that has a doctors degree in agronomy and came home to farm. He has worked several years to gain the education hours needed for certification just to help our school system to have a high school science teacher. He at present only teaches four hours per day due to the size of his farming operation. We always find it very difficult to find a science teacher.

Science teacher is home town product and "farms". Weak disciplinarian.

We are short on the number of science teachers we need in our system.

I only had one application for the opening last summer.

SMITH, Eugene V., married to Evelyn L. Smith, three children. Fighter Pilot WW II, Bachelor degree OCU, Masters degree OSU, 35 years teaching experience. Outstanding Geology Teacher for State of Oklahoma; President and Executive Secretary of Oklahoma Science Teachers Association; Science Specialist, State Department of Education.

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Mr. McCURDY. Thank you, Mr. Smith.

The next panelist is Dr. Don Kellogg, professor of education at East Central State University, in Ada, Okla.

Dr. Kellogg, welcome to the panel. I appreciate your comments.

STATEMENT OF DR. DONALD KELLOGG, PROFESSOR OF EDUCATION, EAST CENTRAL STATE UNIVERSITY, ADA, OKLA.

Dr. KELLOGG. Thank you. I have submitted my testimony, but I would like to make a few comments.

In order to gain some information about the problem we are discussing my colleague, Don Stafford and I initiated some research in January. We are still in the process of analyzing data from that research, but there are some trends that are probably not surprising, but somewhat alarming.

We do find that the majority of Oklahoma science teachers hold standard certificates or higher in the field in which they teach. There are only 8 percent who hold temporary or provisional certificates.

The alarming thing about the 8 percent, No. 1, they are not teaching science because they wanted to; they did not volunteer for the assignment. It was one that was dropped on them. But the more alarming thing is that those 8 percent represent 32 certificate areas. And in 31 of their responses they indicated that they felt their preparation was adequate or above average. This is a little bit alarming.

Additionally, these teachers, a majority responded that their attitude in regard to staying in science teaching ranged from neutral to they would get out at the first opportunity.

Seven and a half percent indicated that they would get out at the first opportunity.

And in regard to the advice that they would give their better science students, 79 percent of them responded that they would either be neutral or would not advise their better science students to go into science teaching. This, of course, represents some attitudinal problems in regard to science teaching on the part of science teachers themselves.

In regard to some of the solutions of the problems we know that money does make a difference in many ways. Because in looking around this room this morning, I see a tremendous number of people who have their college positions, who can thank their college positions to NSF, and summer institutes, many of us got our graduate degrees that way.

The other side of that two-edged sword, is that it also took those people out of the public school classrooms, as they were able to move up.

The reason for leaving the public school classroom is quite obvious when we see that a science major in Oklahoma can go to work in business and industry at an average salary that exceeds $20,000; and a science teacher can go to work at an average salary that is not quite $12,000 for no experience.

I think that we would certainly not want to think that the intellectual caliber of people that are going into science teachers are

those that deliberately choose that salary differential. Consequently, we don't have enough people training for those positions.

The retraining needs for those people who have had the science teaching positions dropped on them is massive. We need a tremendous number of training programs. And, quite frankly, it can't all be up to the Federal Government for those to be provided. There's going to be some problems that will have to be solved at the local level also.

[The prepared statement of Dr. Kellogg follows:]

TESTIMONY

PRESENTED BY

DON KELLOGG

DON STAFFORD

EAST CENTRAL UNIVERSITY

ADA, OKLAHOMA 74820

The following testimony is presented by Drs. Don Kellogg, Professor of Science Education, and Don Stafford, Chairman of the Department of Chemistry, of East Central Oklahoma State University, Ada, Oklahoma. Both Kellogg and Stafford have been active in the improvement of science education for the past 15 years. Each has conducted workshops funded by various agencies including the National Science Foundation, and have served as consultants to public schools and universities throughout the United States. Both have also published extensively in the field of science education.

Also attached, is a copy of the testimony of Ms. Sarah R. Klein, President of the National Science Teachers Association. This testimony was given to the Committee on Science and Technology on February 25, 1982.

The National Picture:

The attached testimony of Sarah Klein accurately describes the national situation related to the teaching of science and mathematics. The testimony provided by Kellogg and Stafford will attempt to add to this portrayal by providing some generalizations concerning the situation in Oklahoma.

The Oklahoma Picture:

There is little question that there is a shortage of science and mathematics teachers on the national level. A myriad of theories, based upon research and/or opinion, have been advanced to explain why this has occurred. Casual observations by anyone associated with science education in Oklahoma will lead to the conclusion that there is also a science and mathematics teachers shortage in Oklahoma. In order to gather more information about the situation, Kellogg and Stafford initiated research in January of 1982.

Survey forms (copy attached) were mailed to 300 science teachers throughout Oklahoma. This group represented a stratified sample randomly selected from Oklahoma Schools. The survey dealt with certification, teachers feelings about activities, advanced training, and the teachers feelings about such items as class load and salary. Teachers were also asked if they would advise top science students to become science teachers. A total of 117 teachers responded to the survey for a return percentage of 39%.

Complete statistical analysis of the data is still in process but a few initial generalizations have been prepared for this testimony.

The responding group of Oklahoma teachers is younger and have less teaching experience than national averages. The Oklahoma group has an average age of 36 and have taught for 10 years compared to the national average age for science teachers of 41 with 16 years teaching experiences. Other data collected from Oklahoma teachers tend to indicate that these averages are simply statistical phenomena and that the Oklahoma averages are closer to those at the national level.

The data show that Oklahoma science teachers are well prepared in terms of certification. Standard certificates or higher were held by 83% of the responding teachers in the field in which they teach. The majority felt

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that their preparation to teach those subjects was adequate or better.

The [illegible]% who hold only provisional or temporary certificates in the areas in which they teach are an interesting sample. This sample represented 99 certificates and the teachers considered themselves to be very well prepared or to have **average** preparation in 91 of the responses! One is tempted to question the validity of these teacher's perception about their preparation.

Based on the data related to certification, one may conclude that about [illegible]% of Oklahoma science teachers hold provisional or temporary certificates in the areas in which they teach. This number would represent rather extensive needs for science teacher training.

According to the data, Oklahoma science teachers teach a wide variety of subjects. The most common dual role is science/mathematics with substantial numbers having science/social studies and science/physical education or science/athletics assignments.

The overwhelming majority of responding teachers reported mild to severe dissatisfaction with both class load and salary. This finding is not inconsistent with other findings from surveys of teachers in general.

The majority of responding teachers had earned less than five hours of college or inservice credit within the last five years. This figure is certain to change as teachers meet the Staff Development requirements of Oklahoma State Law 1706.

Perhaps the most alarming finding in the entire survey was related to Item #21 which examined teachers feelings about their continued involvement as science teachers. A majority of [illegible]% marked a response of [illegible] which indicated that their attitudes ranged from, "uncertain," to, "will leave teaching at the first opportunity." Slightly over 7.5% of the [illegible] teachers indicated that they would leave teaching at the first opportunity.

In response to what advice they would give their own science students regarding a career in science teaching, 16% indicated that they would discourage those students from becoming teachers. A total of 70% scored this item, three or higher. This indicates a range of feelings from "neutral," to, "would not advise these students to go into science teaching."

Conclusions and Recommendations:

Drawing specific conclusions at this point would be premature, until further data analysis is completed. However, initial results [illegible] recent research from the Oklahoma State Department of Education [illegible] to make some tentative conclusions:

1. It would appear that a significant number of Oklahoma science teachers are inadequately prepared for their teaching assignment.

2. A significant number of teachers have left teaching for other careers while a large number would get out of the field if the opportunity became available.

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3. A majority of science teachers are reluctant to recommend science teaching as a career for their better students.

4. Science teachers have concerns about salary and teaching load.

Kellogg and Stafford propose the following recommendations as possible solutions to some of the existing problems.

1. Increased salary for qualified science teachers in order to meet business and industry competition.

2. Retraining programs for those with minimal or no science qualifications. (It takes longer to train an undergraduate than a graduate.

3. Loans for preservice and inservice training. Repayment of loans would be waived for teaching service.

4. Informational programs about science teaching as a career be designed for high school age students.

5. Analysis of state and university requirements for certification of science teachers.

6. Increased support for National Science Foundation activities in Science Education in order to accomplish these recommendations.

7. The establishment of a national committee to study science teaching on a continuing basis.

Mr. McCURDY. Thank you, Dr. Kellogg.

Dr. Joseph Weaver, administrator of teacher testing, the Oklahoma State Department of Education.

Dr. Weaver, thank you for coming, and I appreciate your comments.

STATEMENT OF DR. JOSEPH R. WEAVER, ADMINISTRATOR OF TESTING, OKLAHOMA STATE DEPARTMENT OF EDUCATION

Dr. WEAVER. Thank you, Mr. Chairman. I appreciate the opportunity to appear before the committee and testify on this important issue.

There are three of us who will be presenting testimony today on mathematics education, and I am sure you will introduce the others when the time comes, or I will introduce them now.

Mr. McCURDY. That would be find, if you want to combine all three together.

Dr. WEAVER. We can go directly from mine to theirs, and I will introduce them: Dr. Harold Huneke will be testifying after I testify. And then Dr. Douglas Aichele will testify.

We are going to divide our testimony into three parts, obviously. First of all, I will be dealing with the status of mathematics education in Oklahoma. All of us will be doing that. And we will organize this testimony relative to three groups.

First of all, the present teacher population, then the prospective teacher population, and then the student population. And Dr. Aichele will summarize and offer some conclusions and recommendations.

I think it has already been pointed out today by several people who appeared on the first panel, and by Dr. Kellogg the value of

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the emphasis that was put into science and mathematics education in the early 1960's and 1970's by the National Science Foundation.

We are very fortunate in Oklahome to have a cadre of excellent teachers who receive much of their training during those days through the National Science Foundation support.

This will be reflected in some of the data that we will present in just a few minutes, that we obtained in a survey that was recently done.

Stephen Willoughby who is currently President of The National Council of Teachers of Mathematics, stated recently at a meeting of the Association of State Supervisors of Mathematics, that 60 percent of the mathematics teaching positions in the United States are filled with people who are State certified.

We can be very thankful in Oklahoma, we are better off than this figure would indicate. But preliminary results of a survey that was conducted by the certification section in the State Department of Education does confirm that we have a serious shortage of mathematics and science teachers in Oklahoma.

Another survey that Mr. Smith mentioned earlier was sent out to school superintendents just recently. We had 79 percent of the school districts responding to this survey, and I think that this high rate of response, and the promptness with which they responded indicates the urgency of this matter of teacher shortage.

There are approximately 1,375 teachers that were involved in response to this survey. We agree that holding a standard certificate in the teaching field does not necessarily imply good teaching, but it is one criteria that we have of measuring the quality of education.

I would like to share with you and summarize just a few statements from this survey that we made: first of all, 91 percent of those people teaching half time or more in grades 9-12 have standard certificates. We think that is probably an indication of the effort that was put into mathematics education by the National Science Foundation, and the emphasis that was given to mathematics education on the national scene in the early 1960's

In looking at the years of experience of mathematics teachers in Oklahoma we found that 44 percent of the teachers now teaching and holding standards or provisional certificates have more than 10 years of experience. And another 31 percent of those teachers have between 5 and 10 years of experience.

That simply means that 75 percent of the people who hold standard or provisional certificates in Oklahoma to teach mathematics have more than 5 years of experience.

It would leave some questions about where we are going to be getting the replacements for those people as they retire and move out of the profession.

We have 53 percent of those people teaching less than half time in grades 9-12 who hold standard certificates. And then we have another 36 percent who have certificates in some other subject, and have minor approval credentials in mathematics.

It is very important that we have the flexibility to do that because one of the problems that we pointed out and has been pointed out earlier is the fact that in the smaller schools of the State it

is extremely difficult to get qualified mathematics and science teachers.

Another thing I would like to point out is that in grades 7 through 8—and I think that's a very critical period of time in the educational development of our youth—we have 30 percent of the teaching positions that are half time or more in mathematics are held by people with elementary certificates, with just 12 hours of mathematics.

We found out in this survey that approximately 11 percent of the mathematics positions in the State had been vacated since January 1980 by people leaving the teaching profession and taking non-teaching jobs. We found out 78 percent of the vacancies that occurred in the fall of 1981 were filled by teachers with standard or provisional certificates. That means that there was 22 percent of the jobs that were filled by people that had temporary certificates or teaching on certificates in some other field with a minor credential in mathematics.

One other statistic that I would like to call to your attention is the fact that we found out that 189 vacancies are anticipated in mathematics for the fall of 1982, and Dr. Huneke is going to point out, I think, that we don't have the people that are being produced to fill those vacancies.

I would like to share, just in summary, just some of the statements that were made by administrators who filled out the surveys. And I think we can summarize them in this way. First of all, it's very difficult to find qualified mathematics teachers to fill vacancies in the classrooms as they occur.

Second, finding qualified mathematics teachers is especially difficult in small rural schools in the State.

And the third statement is that the large majority of the statements seem to indicate that higher pay was the one key factor in attracting more people into the teaching profession, in particular in mathematics because of the large number that are going outside of the teaching profession and getting jobs in industry.

STATEMENT OF DR. HAROLD HUNEKE, DAVID ROSS BOYD PROFESSOR OF MATHEMATICS AND EDUCATION, UNIVERSITY OF OKLAHOMA, PRESIDENT OF THE OKLAHOMA COUNCIL OF TEACHERS OF MATHEMATICS

Dr. HUNEKE. I think I may have already performed my most important function today. I let about 15 or 20 people in the parking lot with my gate card. [Laughter.]

I would observe that I've met today about six people who attended NSF Institute on our campus. I wonder if we could have a show of hands of those people here who participated in an NSF Institute.

[Thereupon, several members of the audience raise their hand.]

Dr. HUNEKE. Thank you very much.

Mr. MCCURDY. About 75 or 80 percent of those attending, Harold?

Dr. HUNEKE. These are the people that are really dedicated and still in the teaching profession, probably partly because of the NSF Institute programs.

Everybody in Oklahoma knows about H.R. 1706; its provisions are recorded in the testimony for our visitors. It's an attempt to upgrade the professional standards in Oklahoma.

It does require that teachers pass curriculum exams in courses they are subsequenlty to teach. They have to pay for it. I think it's about $40 for each exam and you have to take several examinations.

There is a question of what the impact of H.R. 1706 will be. If you try to improve the quality will you attract better people? I think this will happen only if pay scales are increased significantly.

To identify the prospective teacher population we sent a questionnaire to all of the State colleges and universities that participate in teacher training, and have the responses back from 13 institutions. These 13 institutions produce over 90 percent of our prospective teachers.

We asked them for the number of students certified to teach secondary mathematics in the year 1970-71, and the number certified in 1980-81. In 1971 there were 198 certified. In 1981 there were 77. That'a approximately a 64 percent decline in the number of prospective teachers.

We also asked them what happened to the 1981 graduates. It appears that approximately 60 percent of those went into teaching. It probably leaves you 46 people in 1980-81 coming out of the State colleges and universities that went into the teaching of secondary mathematics.

Fred Collins of Southeastern State University got a little more interested in this, and provided more data. Here is the data he has. Certified in their program from 1972 to 1980, were 26, 15, 12, 9, 5, 6, 5, 2, and 1.

I would like to read those again. From 1972 to 1980 the numbers certified were 26, 15, 12, 9, 5, 6, 5, 2, and 1. This is from one of the six colleges, our so-called teacher colleges, that were formed as the State of Oklahoma was being developed.

Fred did note that last year, in 1980-81, they did certify ten people, however only one went through their teacher certification program. Others were certified with a major in another area and a minor in mathematics or they transferred from out of the State.

In the questionnaire we asked people to make comments. The following are representative statements: *(a)* "Make salaries competitive. When they can start at $20,000 as a computer programmer, it is hard to take a teacher's salary"; *(b)* "I believe, a number are avoiding teaching of the discipline hassle." I think teachers feel a little bit like Rodney Dangerfield. "I don't get no respect." And I think that's a real problem with the teacher population.

If you take the number of vacancies for 1982-83 indicated by this survey of 189, and assume that in 1981-82 we again have 46 perspective teachers, 189 vacancies and 46 teachers being prepared, we have a problem.

Now, some of those vacancies will be covered by people shifting from one job to the other. However, I would point out that the 189 vacancies reported do not represent all the school districts in Oklahoma.

Another indicator of the prospective teacher population is the number of students taking the curriculum examinations mandated

by H.R. 1706. Since January of this year there have been 63 candidates who have taken the examinations and that seem to fit fairly well with the number of 77 students we had in the teacher programs in 1980-81.

I think it's just really a problem of supply and demand, and in our Nation today money talks very loudly.

Dr. Aichele will talk about our conclusions and recommendations.

STATEMENT OF DR. DOUGLAS B. AICHELE, PROFESSOR OF MATHEMATICS AND HEAD OF THE DEPARTMENT OF CURRICULUM AND INSTRUCTION, OKLAHOMA STATE UNIVERSITY, PRESIDENT OF SCHOOL SCIENCE AND MATHEMATICS ASSOCIATION

Dr. AICHELE. Thank you. I drove down here in a white car with an OSU seal, and I didn't get into the parking lot; but that's because we didn't come to the right gate. [Laughter.]

I would like to take a few minutes and talk a little bit about the student population; really that's the third area in our study of Oklahoma's mathematical needs. And then I will go directly to the conclusions and recommendations.

Some of the questions that arose in the 1960's concerning calculus being taught in high school and the joining of algebra and trigonometry, those kinds of issues, are spoken to in the first table in part 3 of our prepared statement that you have.

You can see that in the late 1970's algebra and trigonometry were being taught independently more regularly and more students were taking trigonometry; also, calculus is being taught in high school.

There are also others that show up in some of these tables. I guess one of the most obvious is that secondary students are taking less mathematics above geometry, and the percentages of 17 year-olds both nationally and in Oklahoma support that statement.

And there's another that I think is critical, and reflects a prevalent attitude. Last year nearly 21 percent of Oklahoma secondary students were enrolled in either high school mathematics, consumer mathematics, or vocational mathematics, that is one out of five students were enrolled in the most basic of high school mathematics classes.

We are fortunate that in Oklahoma we have many opportunities for postsecondary education. An increasing number of the major areas of study in college require more mathematics, thus requiring better precollege preparation. One measure of preparedness is the score of the mathematics portion of the ACT administered to college-bound students.

Nationally, the mean mathematics score and composite score were respectively 17.4 and 18.5 for 1979-80. In Oklahoma for the same period, the scores were 16 and 17.8; and the score of 16 is statistically significantly less than the national average.

Another measure of preparedness is the number of years of high school mathematics required for graduation. And I think this is a revealing statistic—and we will followup on this in the recommendation. Graduation from an Oklahoma high school requires comple-

tion of 1 year of mathematics. However, 164 of the 457 Oklahoma school districts (or about 36 percent) require more than 1 year of mathematics.

And another fact is that approximately one-third of the mathematics credit load at the University of Oklahoma and Oklahoma State University is at a level lower than calculus.

I would now like to briefly review some of our recommendations and conclusions, which are listed in part 4 of our prepared statement. Please consult report directly. We divided this part of our statement into the present teacher population, prospective teacher population, and the student population.

As far as the present teacher population, one of our recommendations is that the Oklahoma Legislature and local school districts continue to provide pay raises and other incentives for all teachers. And I think it is a key to note, "and other incentives". Also, differential pay for teachers in areas of short supply should be considered.

The second recommendation is that an awareness mechanism be found to alert the public to the problem and increase their support of and recognition of teachers. There is an acknowledgement of a successful awareness program that was conducted in North Carolina (for the record).

Prospective teacher population recommendations include the following—and note that for prospective teachers there are really two subpopulations: one population is that group that is being certified for the first time, and the second is the group that is certified in another area and is seeking certification of mathematics. When we speak about prospective teachers, we are speaking about both populations.

First, that the pay for beginning mathematics and science teachers be raised to a level commensurate with the positions that they would be qualified for in private industry. Second, that the State and national scholarship and loan program be reserved for prospective teachers in areas of short supply. We heard this recommendation spoken to earlier.

Third, that institutes for science and mathematics be established for teachers currently certified in those areas. And fourth, that school counselors and parents and other personnel who are involved in helping students make career choices alert the students to the shortage of mathematics and science teachers.

Fifth, that women and minorities be encouraged to seek careers in scientific areas. Sixth, that the State Department of Education continue to monitor documents and report the areas of teacher demand and supply.

And finally, our recommendations with regard to the student population. First, that school districts upgrade their mathematics and science activity standards. Second, that school districts and parents, mathematics teachers and so forth encourage students who plan to enter college to take at least 3 years of college preparatory mathematics. Third, that students be encouraged to explore the opportunities in the teaching profession. And fourth, that school districts be encouraged to employ mathematics and science specialists in their elementary and middle schools.

That concludes our report.

[The statement of Drs. Weaver, Huneke, and Aichele follows:]

TESTIMONY

Presented to

Science, Research and Technology Subcommittee
of the
U.S. House of Representatives

by

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INTRODUCTION

In 1957 the launching of the Sputnik Satellite by Russia ignited a burst of activity in mathematics and science education. Some evidence of this effort can still be seen today. We have a cadre of excellent teachers who received training in National Science Foundation sponsored institutes and other workshops and seminars generated by the national concern for mathematics and science education during the 1960's and early 1970's. These teachers have in turn produced many outstanding students who are making significant contributions in mathematics and scientific fields. We have been able to glean much that is good from the curriculum projects that were implemented during the early years following Sputnik.

However, there is evidence that we are losing some of the ground we gained in mathematics education. There are numerous problems facing the mathematics education community. None of these problems is more critical than that of supply and demand of qualified mathematics teachers. According to Stephen Willoughby, President of The National Council of Teachers of Mathematics, 60% of the mathematics teaching positions in the United States are filled by people who are state certified. Preliminary results of a survey being conducted by the Certification Section of the Oklahoma State Department of Education confirm that there is a serious shortage of mathematics and science teachers in Oklahoma.

Dr. Harold Taylor of San Mateo, California, recently presented testimony to The National Commission on Excellence in Education. This testimony is included as Appendix B of this report and deals with the problem of mathematics education at the national level. We will confine our testimony to the status of mathematics education in Oklahoma. Our testimony is organized relative to three groups - the present teacher population, the prospective teacher population, and the student population.

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Part I - Present Teacher Population

A letter and questionnaire was sent on April 5, 1982 from the State Department of Education to the superintendents of all independent school districts in Oklahoma. The questionnaire asked for information on the status of those now teaching mathematics and science. A copy of the letter and the questionnaire with the results tabulated is in Appendix A. Seventy-nine percent of the school districts responded. The high return rate of the survey and the promptness with which survey forms were returned indicate the urgency school administrators feel about the shortage of mathematics and science teachers.

The results involve approximately 1,375 teachers. The majority of the questions dealt with the certification status of these teachers. We agree that holding a standard certificate does not always imply good teaching. Some of the more interesting results are indicated below:

1. From question 3(a) we note that 91% of those teaching half-time or more in grades 9-12 have standard certificates. This is probably related to the results in (7) which indicates that 44% of the teachers have more than 10 years experience and 31% have 5-10 years of experience. Oklahoma is very fortunate to have this cadre of experienced teachers.

2. From question (4) we note 53% of those teaching less than half-time in grades 9-12 have standard certificates with 36% having a certificate in another subject and a minor approval credential in mathematics.

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3. From question (6) we note that 30% of those teaching more than half-time in grades 7-8 hold an elementary certificate with 12 hours of mathematics.

4. Question (7) indicates a teaching population which is very experienced but raises the question of replacements when these teachers retire.

5. From question (8) we note that approximately 11% of the mathematics teachers have left teaching since January 1980 to take non-teaching jobs.

6. Questions (9) and (10) indicate that only 78% of the vacancies in the fall of 1981 were filled by teachers with a standard or provisional certificate.

7. In question (11) the schools reporting indicate 189 anticipated mathematics vacancies in 1982-83.

A sample of the comments from the respondents to the questionnaire are included here with others included in Appendix C.

"Math teachers, at least good strong teachers, are difficult to find and hold. We employed three and lost them (this year)."

"There is only one sure solution in my opinion. That is the beginning salary must be raised to a level that is comparable to other professions with like standards and requirements. The teaching profession can and should be upgraded. This will only happen if salaries are increased to a reasonable amount."

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"Salaries must be competitive as well as job conditions."

"This is the first math teacher we have had in three years and he only has a minor and has not been satisfactory." (Grades 7-12 with 280 students)

"Math teacher is hometown - farms, is good teacher." (Grades 7-12 with 261 students)

"If the anticipated vacancy becomes a reality it will be trouble! I have 0 applicants who have more than 6 hours of math. Oil companies pay them too well for them to teach school and live from one pay check to the next. Plus those I've talked to aren't willing to put up with the regulation of 1706 when they can get a better job anyway."

"More money for these teachers - Bonus for Math."

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Part II - Prospective Teacher Population

As part of the background for this testimony some provisions of H.B. 1706, which was passed by the Oklahoma Legislature in 1980, should be noted.

1. The entry requirements into teacher education programs were upgraded.

2. Teacher candidates are required to pass a curriculum examination in their teaching area.

3. First year teachers are required to serve under the supervision of entry year assistance committee.

4. All educational personnel are required to participate in a staff development program.

A questionnaire was sent to all of the four-year institutions in Oklahoma asking them to indicate the number of students who completed requirements for Standard Certificates during the academic years 1970-71 and 1980-81. Academic year to mean first semester, second semester and summer. For 1980-81 they were asked to indicate the type of position the students accepted.

Thirteen schools reported as of the date of this report including all of those most involved in teacher training. The data is in the table below:

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1971	1981	Teaching	Non-Teaching	Graduate School	No Info.
198	77	26	8	3	40

Two important implications can be made from the results:

1. From 1971-81 there has been a drop of approximately 64% in the number of students completing the requirements for a standard certificate.

2. If one assumes that one-half of students for which no information was available go into teaching then 60% of those attaining a standard certificate take teaching positions.

Dr. Fred Collins of Southeastern State University provided more detailed information on the students who have gone through their teacher certification program.

1972	1973	1974	1975	1976	1977	1978	1979	1980
26	15	12	9	5	6	5	2	1

Although only one student went through their program including student internship in 1980-81, nine others were certified having taken their student internship in another subject and acquired enough hours in mathematics or transferred from another state, etc.

The questionnaire provided a space for comments and some typical ones were:

1. Make salaries competitive. When they can start at $20,000 as a computer programmer, it is hard to take the teachers salary.

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2. I believe a number are avoiding teaching because of the discipline hassle.

If one extrapolates the 1980-81 data to 1981-82, that is 77 certified and 46 of those taking teaching jobs and compares this with the anticipated job openings of 189, it is obvious that school administrators will face a difficult problem in finding mathematics teachers. Some of the vacancies will be filled by teachers transferring to another teaching position. However, it should be noted that the figure of 189 is taken from the schools that reported so the actual number of vacancies will be larger. An examination of the individual questionnaires indicate that recruitment is less of a problem for schools in urban areas.

Another indicator of the number of prospective teachers is the required proficiency examinations in mathematics for new teachers which were mandated in H.B. 1706. A total of 63 candidates have been tested in secondary mathematics since January 1982. Some of these may be students with majors in other areas who wish to teach mathematics as a minor assignment. Of course there is no guarantee that the candidates will enter the teaching profession. The number of 63 taking the exams seems to be consistent with the extrapolated number of 77 who will complete the course requirements for certification.

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PART III

STUDENT POPULATION

In the Report of the 1977 National Survey of Science, Mathematics and Social Studies Education,[1] course enrollments in secondary mathematics were surveyed and compared for academic years 1972-73 and 1976-77. The table below indicates some of the trends.

Course Enrollments in Secondary Mathematics
1972-73 and 1976-77[2]
(in Thousands)

	1972-73	1976-77
General Mathematics 9-12	2417	2563
Business Mathematics 9-12	392	609
Elementary Algebra	2052	2825
Advanced Algebra	1808	1317
Geometry	1506	1900
Trigonometry	171	460
Probability/Statistics	25	39
Computer Mathematics	63	153
Advanced Senior Mathematics	259	225
Calculus	55	105

Some of the differences appear to conform to beliefs commonly maintained by mathematics educators; some are more surprising. School geometry, for example, shows no signs of decline, and enrollment increases in computer mathematics and calculus suggest that students are being prepared in these areas. However, the enrollments in advanced algebra and advanced senior mathematics declined during this five-year period.

There is concern that while some students are receiving advanced high

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school mathematical experiences, there is a large body of students who terminate their mathematics preparation after geometry. This concern is illustrated in the table below.

Percent of 17-Year-Olds
Who Had Taken Various Mathematics
Courses (1977-78)[3]

Elementary Algebra	72.1
Geometry	51.3
Advanced Algebra	36.9
Trigonometry	12.9
Probability/Statistics	2.7
Computer Mathematics	5.0
Precalculus or Calculus	3.9

In Oklahoma, the 1981-82 school enrollment is 262,794 (grades 7-12), which reflects a 9% decrease over the 1977-78 school enrollment. Enrollments and associated percentages by courses during 1980-81 are given below.

Number and Percent of Oklahoma Students
Enrolled in Various Mathematics Courses (1980-81)[4]

Elementary Algebra	26,938	(60.3)
Geometry	13,216	(29.0)
Advanced Algebra	11,684	(25.5)
Trigonometry	2,496	(5.5)
Probability/Statistics	0	(0.0)
Computer Mathematics	1,006	(2.2)
Precalculus or Calculus	1,636	(3.9)

Additionally, 9,543 Oklahoma students (20.9 percent) were enrolled in either high school mathematics, consumer mathematics, or vocational mathematics

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courses during 1980-81. This pattern of course enrollment is representative of the immediate past five-year period.

We are fortunate that Oklahomans have many opportunities to receive post-high school education. An increasing number of the major areas of study in college require more mathematics, thus requiring better precollege preparation. One measure of preparedness is the score on the mathematics portion of the ACT administered to college-bound students. Nationally, the mean mathematics score and composite score were 17.4 and 18.5, respectively, for 1979-80. In Oklahoma for the same period, the respective scores were 16.0 and 17.8--the mathematics score being significantly lower than the corresponding national mathematics score. Another measure of preparedness is the number of years of high school mathematics required for graduation. Graduation from an Oklahoma high school requires completion of one year of mathematics; however, 164 of the 457 Oklahoma school districts require more than one year of mathematics.[5] The fact that approximately one-third of the mathematics credit load at Oklahoma State University and the University of Oklahoma is for courses at the level below calculus further illustrates the lack of preparation in mathematics.

References

1. Weiss, I. Report of the 1977 National Survey of Science, Mathematics and Social Studies Education. Research Triangle Park, North Carolina: Research Triangle Institute, 1978.
2. Fey, J. "Mathematics Teaching Today: Perspectives from Three National Surveys," What Are the Needs in Precollege Science, Mathematics and Social Studies Education? Views from the Field. National Science Foundation (SE 80-9), 1979, p. 21.
3. National Science Foundation. Science Education Databook (SE 80-3).
4. Oklahoma State Department of Education.
5. Ibid.

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PART IV

CONCLUSIONS AND RECOMMENDATIONS

Present Teacher Population

The Oklahoma legislature is to be commended for the significant pay raises for teachers that they have made possible for the past few years. As noted earlier in the report, 44% of the mathematics teachers have more than 10 years of experience and 31% have more than 5 years of experience. In view of the greatly reduced numbers of prospective teachers, it is crucial that these experienced teachers remain in the classroom.

Recommendations:

1. That the Oklahoma legislature and local school districts continue to provide pay raises and other incentives for all teachers. Also, differential pay for teachers in areas of short supply should be considered.
2. That an awareness mechanism be found to alert the public to the problem and increase their support of and recognition of teachers. A successful awareness program was established in North Carolina through the Governor's Board of Science and Technology and its Committee on Science and Mathematics Education. Committee representation was broad and included public school teachers, administrators, college professors, and State Department of Education supervisors in science and mathematics.

Prospective Teacher Population

As noted previously, Oklahoma has a large cadre of dedicated mathematics teachers. The big question is: "Who will replace them?" If the present situation of a low production of mathematics and science teachers persists, the long-range effect can be devastating to a country that has a great tradition

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in scientific achievement. Poor teaching or poorly qualified teachers can cause students to reject the study of mathematics. If this occurs early in a student's career, it is very difficult to make up deficiencies--even if the student's career choice demands mathematics. It is imperative that this nation increase its supply of well-qualified mathematics and science teachers.

Recommendations:

1. That the pay of beginning mathematics and science teachers be raised to a level commensurate with positions they would be qualified for in private industry.
2. That state and national scholarship and loan programs be reserved for prospective teachers in areas of short supply. Superintendent David Williams of Durant, Oklahoma suggested that the student loan program cancelling a percent of the loan for each year of teaching service should be considered.
3. That institutes for science and mathematics coursework be established for teachers currently certified in other areas.
4. That school counselors, parents, and other personnel who are involved in helping students make career choices alert the students to the shortage of mathematics and science teachers.
5. That women and minorities be encouraged to seek careers in scientific areas.
6. That the State Department of Education continue to monitor, document, and report areas of teacher demand and supply.

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Student Population

Approximately 88% of Oklahoma high school students take fewer than four years of college preparatory mathematics. This reduces drastically their career choices, even though they try to make up the deficiency later in college work.

Recommendations:

1. That school districts upgrade their mathematics and science academic standards.
2. That school counselors, parents, mathematics teachers, etc. encourage students who plan to enter college to take at least three years of college preparatory mathematics.
3. That students be encouraged to explore the opportunities in the teaching profession.
4. That school districts be encouraged to employ mathematics and science specialists in their elementary and middle schools.

We truly appreciate the interest expressed in this topic and the opportunity to present testimony today.

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APPENDIX A

J.D. GIDDENS
ASST. SUPERINTENDENT
INSTRUCTION

JACK STRAHORN
ASST. SUPERINTENDENT
STATE FEDERAL

MURL VENARD
ASST. SUPERINTENDENT
FINANCE

State Department of Education

LESLIE FISHER, Superintendent
LLOYD GRAHAM, Deputy Superintendent
TOM CAMPBELL, Associate Deputy Superintendent
JOHN FOLKS, Associate Deputy Superintendent

2500 North Lincoln Boulevard
Oklahoma City, Oklahoma 73105

April 5, 1982

Dear Superintendent:

There is developing a severe shortage of mathematics and science teachers in the United States. We are aware there is a problem in Oklahoma but we lack hard data to document the level of severity. Before steps can be taken to correct the problem, there is a need to make the public, legislators, and students who are potential teachers, aware of the problem.

An excellent opportunity has developed to bring the problem to the attention of the public. The office of David McCurdy, Congressman from the Fourth District, is arranging a meeting of the Subcommittee on Science, Research and Technology to be held in Oklahoma on May 7, 1982. Representatives will be present from the National Science Foundation, the American Association for the Advancement of Science, the National Council of Teachers of Mathematics, the National Science Teachers Association, the Oklahoma Council of Teachers of Mathematics, the Oklahoma Science Teachers Association, the School Science and Mathematics Association and the State Department of Education. Legislators and others involved in mathematics and science programs in Oklahoma will also be represented on panels. We have been asked to provide data on the status of mathematics and science teachers. We need your help.

We are gathering data on the decline in the number of teachers certified and the number of those certified who decided not to teach. In the time frame imposed on us, only you can provide us with the other information needed.

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Please fill out and return the enclosed questionnaires as soon as possible so that we can prepare the data. One questionnaire asks for information concerning mathematics education and the other asks for information concerning science education. We are trying for an April 20 cut-off on the data.

Please return the questionnaires to:

Dr. Joseph R. Weaver
State Department of Education
2500 North Lincoln Boulevard
Oklahoma City, Oklahoma 73105.

We wish to assure you that the results will remain confidential and the data will not list individual schools or districts. A copy of the results will be sent to you if requested. Our hope is that by clearly identifying the problem, a start can be made to obtain a solution, then you as an administrator may not be faced with that frantic search for mathematics or science teachers each August.

Thanks for your help in documenting the problem.

Sincerely,

Leslie Fisher
State Superintendent

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Enclosures

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QUESTIONNAIRE - MATHEMATICS

1. What is the total student enrollment in your school district? _____

2. How many teachers in grades 9 - 12 have a teaching assignment of one-half time or more in mathematics? _____

3. Of those listed in Item 2, how many hold a

   (a) Standard Certificate in mathematics? _____

   (b) Provisional Certificate in mathematics? _____

   (c) Temporary Certificate in mathematics? _____

4. How many teachers in grades 9 - 12 have a teaching assignment of less than one-half time in mathematics? _____

5. Of those listed in Item 4, how many hold a

   (a) Standard Certificate in mathematics? _____

   (b) Provisional Certificate in mathematics? _____

   (c) Temporary Certificate in mathematics? _____

   (d) Certificate in another subject and a minor approval credential in mathematics? _____

6. How many teachers who teach mathematics in grades 7 - 8 one-half time or more hold a

   (a) Standard Certificate in mathematics? _____

   (b) Provisional Certificate in mathematics? _____

   (c) Temporary Certificate in mathematics? _____

   (d) Elementary Certificate with 12 hours of mathematics? _____

7. For those on your staff who hold a standard or provisional certificate in mathematics, indicate the number having the following years of experience, including this school year:

   1 year _____, 2 years _____, 3 years _____, 4 years _____,

   5 to 10 years _____, more than 10 years _____.

8. How many mathematics teachers have left your staff since January 1980 to take non-teaching jobs? _____

9. How many vacancies did you have in mathematics at the end of the 1980-81 school year? _____

10. How many of these vacancies were you able to fill with a teacher holding a standard or provisional certificate in mathematics? _____

11. How many vacancies in mathematics do you anticipate for the 1982-83 school year? _____

12. Comments (possible solutions, quality of teachers, etc.; use the back of the page if needed):

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Dr. Joseph R. Weaver
State Department of Education
2500 North Lincoln Boulevard
Oklahoma City, Oklahoma 73105

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QUESTIONNAIRE - MATHEMATICS

1. What is the total student enrollment in your school district? _____

2. How many teachers in grades 9 - 12 have a teaching assignment of one-half time or more in mathematics? 952

3. Of those listed in Item 2, how many hold a
   (a) Standard Certificate in mathematics? 855 (91%)
   (b) Provisional Certificate in mathematics? 54 (6%)
   (c) Temporary Certificate in mathematics? 30 (3%)

4. How many teachers in grades 9 - 12 have a teaching assignment of less than one-half time in mathematics? 155

5. Of those listed in Item 4, how many hold a
   (a) Standard Certificate in mathematics? 91 (53%)
   (b) Provisional Certificate in mathematics? 11 (6%)
   (c) Temporary Certificate in mathematics? 8 (5%)
   (d) Certificate in another subject and a minor approval credential in mathematics? 63 (36%)

6. How many teachers who teach mathematics in grades 7 - 8 one-half time or more hold a
   (a) Standard Certificate in mathematics? 468 (61%)
   (b) Provisional Certificate in mathematics? 52 (6%)
   (c) Temporary Certificate in mathematics? 11 (1%)
   (d) Elementary Certificate with 12 hours of mathematics? 231 (30%)

7. For those on your staff who hold a standard or provisional certificate in mathematics, indicate the number having the following years of experience, including this school year:

   1 year 94 (7%), 2 years 67 (5%), 3 years 96 (7%), 4 years 81 (6%),
   5 to 10 years 429 (31%) more than 10 years 607 (44%)

8. How many mathematics teachers have left your staff since January 1980 to take non-teaching jobs? 145

9. How many vacancies did you have in mathematics at the end of the 1980-81 school year? 261

10. How many of these vacancies were you able to fill with a teacher holding a standard or provisional certificate in mathematics? 203

11. How many vacancies in mathematics do you anticipate for the 1982-83 school year? 189

12. Comments (possible solutions, quality of teachers, etc.; use the back of the page if needed):

Please return to:

Dr. Joseph R. Weaver
State Department of Education
2500 North Lincoln Boulevard
Oklahoma City, Oklahoma 73105

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APPENDIX B

Testimony

Presented to

The National Commission on Excellence in Education

by

Harold D. Taylor

My name is Harold D. Taylor. I am a classroom teacher of mathematics at Hillsdale High School in San Mateo, California, a position I have held for the past sixteen years. Prior to coming to San Mateo, I was a mathematics teacher in Patterson, California, Covelo, California and in the State of New Mexico. I have been in public education for twenty-three years. I received my B.S. and my M.A. in mathematics and Ed. D. in mathematics education from the University of Northern Colorado. I am a member of the Board of Directors of the National Council of Teachers of Mathematics and a past-president of the California Mathematics Council, Northern Section.

I am pleased to have the opportunity to appear before the National Commission on Excellence in Education to testify on behalf of mathematics education. I represent the approximately 60,000 members of the National Council of Teacher of Mathematics. The Council is dedicated to achieving excellence in mathematics education at all levels, kindergarten through university, and we strive to achieve our goal through the dedication of classroom teachers throughout our nation.

Mr. Chairman, it gives me great pleasure to appear before you today on behalf of all classroom teachers of mathematics. Your Commission's concern for the status of mathematics and science education gives us hope that, working together, we can effect a reversal in the trend toward technological illiteracy in this country, and thus to its threat to our national economy and our national security.

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I wish to place my testimony in the following context:

1. The youth of this country is our most valuable natural resource;
2. The classroom teacher is the heartbeat of free public education;
3. Our national economy and our national security are already seriously compromised:
4. Immediate action on the part of both state and federal governments is essential in order to reverse the current trends in mathematics and science education; and
5. The education of our youth must become a pressing national commitment.

The decline in the mathematical ability of entering college freshmen and the resulting decrease in the number of students who elect majors in science represents a crisis in education. The fact that this problem exists is documented in a report by Joan R. Leitzel of The Ohio State University, to the American Association for the Advancement of Science, and reported in the Chronicle of Higher Education, in January 1982.

Recent studies have shown that the United States is lagging Japan, West Germany, Eastern Europe, and Russia in the production of engineers and scientists. For example, in 1979 Japan produced approximately 22,000 electrical engineers, while the United States produced only slightly over 16,000. These figures are in contrast to somewhat less than 12,000 electrical engineers for Japan and slightly over 16,000 for the United States ten years earlier. While considering these figures, it must be kept in mind that Japan has about one-half the population of the United States. Our domination of the field of high technology is seriously compromised by failure to train engineers and scientists, and thus, our national economy and our national security are surely threatened. We had a trade deficit with

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Japan in 1981 of $18 billion with a deficit that is projected to go to $20 billion in 1982. According to Project Atlas, Richardson, Texas, 1981, engineers accounted for 6% of the bachelors degrees awarded in the United States during 1980. Comparable percentages are: Japan 21%, West Germany 37%, and Eastern Europe 42%. The American Electronics Association projected that in 1981 U.S. colleges and universities would produce only 43% of the demand for new graduates in the electronics industries.

The reasons for the decline in student mathematical ability are complex and difficult to formulate. I believe, however, the primary culprit is our curriculum. At almost all levels of education, our curriculum is geared too low. We teach to the average or below average student, our curriculum materials are directed to the average or below average student, and far too small a portion of teacher time is directed toward those who are capable. Classroom behavior of students is such that a teacher's energy must be directed toward keeping discipline, rather than teaching. School attendance is often a problem. Education is forced to compete with television, sports, electronic games, drugs, alcohol and sex for student time and interest.

I am thoroughly convinced that our compulsory education laws are antiquated and need replacing. Large numbers of students who consider school attendance to be a jail sentence, and behave accordingly, are forced by law to be enrolled in our schools. Physical, verbal, and psychological abuse of teachers is commonplace on school campuses. Vandalism, including arson, costs schools far too great a portion of their resources, both human and financial. These students

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cause the public to pay for educating them year after year, over the same subject matter and still often graduate illiterate. In short, they are a small minority of the total number of students, but demand a disproportionately large share of the school's time and resources and the public's money. They should no longer be forced to attend traditional schools. Alternatives must be provided them through continuation schools, technical schools, vocational schools, or work groups, such as the California Conservation Corps. Legislation must be enacted whereby student discipline can be controlled.

Another factor in the decline of mathematical ability of students in the long-standing practice of social promotion, especially in the elementary and middle schools promotion, especially in the elementary and middle schools. A student's advancement into secondary school often is a function of years spent in school rather than performance in academic subjects. The advancement of a student into higher grades, without the accompanying skills, is an insurmountable obstacle in the way of further academic progress. The second national assessment of mathematics has pointed out the critical need for attention to higher-order cognitive skills. Almost every student is seriously deficient in reasoning and listening skills and very few have developed even reasonably good study habits by the time they reach the secondary level. A high school diploma often represents time spent in school rather than student achievement. Grade inflation seriously detracts from the value of the diploma and makes college entrance requirements, with respect to grade point average, meaningless.

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The attitudes of teachers, students, parents and the public at large, impact the learning of mathematics. Students who want to learn and are prevented from doing so are frustrated and tend to blame the school and their teachers. Parents, and the general public, those who provide the financial support for education, blame the schools and teachers for not doing a better job. They have voiced their displeasure at the ballot box by voting down bond measures and voting in tax reform. Teachers feel they are neither respected nor appreciated. In such a setting of frustration and unhappiness, mathematics education cannot attain excellence.

It must be understood by those who criticize mathematics teaching as bland, that educating oneself is a personal responsibility, is hard work, and is often boring. Some of the strongest motivation to which human beings respond is extrinsic, rather than intrinsic. Teachers are not trained as entertainers, they are not paid as entertainers, and cannot be expected to motivate students to study mathematics by entertaining them. Critics must understand that the typical secondary teacher of mathematics not only must meet 150 students in the classroom each day, five days a week, but must make and grade tests, evaluate homework, send progress reports or grade reports each month, plan lessons, keep records, write college and job recommendations for students, maintain communication with parents and counselors and administrators, tutor students who have been absent or fallen behind for other reasons, develop and plan curriculum, and numerous other tasks. Meanwhile, they must maintain discipline in the classroom and survive many classroom interruptions.

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Some teachers in our classrooms also contribute to the decline in student's mathematical ability. In our elementary schools many teachers suffer math anxiety and pass this along to their students. A teacher who is excellent in other subjects, and elementary teachers are expected to be expert in all subject areas, quite often is not a good mathematics teacher. There are some states that do not require an elementary teacher to study mathematics beyond basic arithmetic in grade 9. Poor mathematics teaching is not restricted, however, to the elementary level. Some states do not require that secondary teachers of mathematics study even up to the level they may teach.

Before we can attain excellence in mathematics education, our classrooms must be staffed with well trained, dedicated teachers. The Association for School, College and University Staffing indicates that 22% of all high school teaching posts in mathematics are vacant at the present time. At the same time, the National Council of Supervisors of Mathematics reports that 26% of the mathematics positions are filled by teachers who are not certified, or are only temporarily certified to teach mathematics. As a specific example, in Maryland, a survey by the State Department of Education at the end of the 1979-1980 school year estimated that 50,000 secondary students received their mathematics instruction from more than 400 teachers who were not certified to teach secondary mathematics. Howe and Gerlovich in their National Study of the Estimated Supply and Demand of Secondary Science and Mathematics Teachers, said that 43 of 45 reporting states indicate a shortage or a critical shortage of secondary mathematics teachers. Because of the shortage of mathematics teachers and the over supply in other areas, there continues to be

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more and more teachers assigned to teach mathematics who have neither the training nor the desire to do so.

Kenneth Ashworth, Texas Commissioner of Higher Education, stated that in 1978, in the entire South, colleges graduated 445 mathematics education majors and 7502 coaches and physical education majors. The 1980 Conference Board of the Mathematical Sciences Survey shows that the number of mathematical science bachelor's degrees with majors in secondary teaching has dropped by 64% since 1975. Few people are choosing to become teachers of mathematics. The profession simply is not attractive enough to draw students in sufficient numbers. The salary differential between business and industry and teaching is far too great and the working conditions simply not good enough to attract potential candidates. If we are to attract an adequate supply of teachers of mathematics for our nation, and we must, these deterrents have to be eliminated. William S. Graybeal reported in The Mathematics Teacher in December of 1979 that the average salary of a beginning teacher with a bachelor's degree was only 73.1% of the beginning salary offered by private industry to bachelor degree graduates in mathematics and statistics. This ratio has steadily declined and is presently no more than 60%. U.S. News and World Report has stated that, "Math teachers coming out of college already realize that the $12,000 paid to a beginning teacher is a lot less than the $20,000 they could earn in the first year with some computer firms. What's more, many say they feel more appreciated in private sector jobs than in classrooms."

In February, 19822, U.S. News and World Report stated that, "Alleviating the math-teacher shortage is one of the most immediate

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and pressing tasks facing colleges and school systems." I wholeheartedly agree. The time has come for differential pay to mathematics teachers! Houston, Texas has already implemented such a plan, with no major difficulties, and the plan is being expanded for the academic year 1982-73. The precedent for differential salaries has been set by school districts throughout the country that have paid incentives for teaching in inner city schools. All teachers in short supply should be offered incentives to enter, or to remain in, the profession.

If teachers trained in fields other than mathematics are to teach mathematics, they should be retrained to the extent necessary to become well qualified. All teachers must undertake a continuing education program just as attorneys and medical doctors do. Groups such as the National Council of Teachers of Mathematics and the California Mathematics Council offer excellent opportunities for continuing education through their publications and their many sectional, regional and national meetings each year. Local school districts, states, and counties have the obligation to offer opportunities for self improvement to classroom teachers. The teacher training institutions must offer summer programs for the continued training of teachers as they once did, under the financial leadership of the National Science Foundation. One of the most important contributions to the strengthening of our mathematics and science instruction in this nation was that of the National Science Foundation grants and programs offered after SPUTNIK in 1957

The public at large, and especially state and federal governments and courts, must stop expecting our schools to be a major ve-

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hicle for social change. Please note that on February 6, the President released his fiscal year 1983 budget proposal with recisions for fiscal 1982. He not only asked for the dismantling of the Department of Education, but that science and engineering education be funded, through the National Science Foundation, for the amount of $9.9 million. At the same time, he asked for bilingual education to be funded, through the same authority, in the amount of $126 million. Bilingual education requirements, bussing for racial integration, rehabilitation of juveniie delinquents, problems created by a high divorce rate and families where both parents work, and malnurished and abused children are but a few of the social problems that public schools are expected to solve. We are not equipped nor trained to handle these problems.

If given the financial, philosophical, legislative and societal backing, the problems that exist in public education can be solved. This solution cannot occur overnight, and since we are currently in a state of crisis with respect to mathematics education, it is imperative that a plan for a solution be formulated immediately and that we, as a nation, dedicate our energies and resources to the implementation of that plan. We must have teachers trained to each mathematics in the classrooms at all levels, grades one through twelve. With proper support, the development of reasoning, listening, and reading skills can start in the first year of a student's formal educational training. The proper attitudes toward studying and learning mathematics should be developed beginning with grade one. It is exceptionally important that we begin to generate computer literacy and the rudiments of computer programming with all our students. Let me hasten to say that pouring money into education

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does not guarantee excellence. Our expenditures must be carefully considered and indiscriminant and wasteful spending avoided.

I shall use the Resolution on Technological Innovation proposed by the National Governor's Association Task Force on Technological Innovation as an example of an ineffective strategy for achieving excellence in mathematics education. This task force was co-chaired by Governor Brown of California and Governor Milliken of Michigan and was adopted at the National Governor's Conference in February 1982. It stated, in part, that: Be it resolved that the states and the federal government join with business, labor and academic leaders to:

1. Channel capital investment toward technological innovation and transformation of our economic base;
2. Demand excellence in math, science, engineering and computer sciences in our schools and universities; and
3. Provide sufficient vocational education and on-the-job training for the new jobs in micro-electronics, computers, robotics, tele-communications and biotechnology.

The key term used by the authors of this resolution, as passed by the states' governors, is DEMAND! It must be noted that according to this resolution, they will ASSIST technological innovation by channeling capital investment in the proper direction, they will PROVIDE sufficient vocational education and on-the-job training to assist the high technology industries, but they will DEMAND excellence in math, science, engineering and computer education.

Certainly this is a most naive approach to solving the problems that exist in achieving excellence in mathematics and science education. While it is most easy to DEMAND, it does nothing toward a

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solution. In fact, such a demand, with no assistance to the profession for implementation, is probably detrimental.

In summary, in my testimony to you here this morning, I have called for the following:

1. A national commitment to the training of mathematics teachers, on a level at least equal to what was done through the National Science Foundation in the late 50's and early 60's;
2. An end to the practice of staffing mathematics classrooms with the overstaffing from other subject areas;
3. Placing mathematics specialists and mathematics teachers in our elementary school classrooms as well as in the secondary classroom;
4. A commitment on the part of teachers to professional organizations and continuing education;
5. The dedication of teachers to the improvement of mathematics education;
6. Differential pay for teachers who are in short supply;
7. An end to social promotions;
8. A major upgrading of academic standards;
9. A change in compulsory education laws;
10. Legilation to allow for the enforcement of standards of student behavior;
11. A national financial commitment to education through state and federal governments; and
12. A national philosophic commitment to free public education opportunities for all who live in the United States.

It has, indeed, been an honor for me to appear before you this morning. I thank you for your kind attention.

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CERTIFICATION QUESTIONAIRE

Please indicate the number of students who completed the requirements for certification at your school during the academic years indicated. Academic year to mean first semester, second semester and summer. For 1980-81 indicate the type of position the student accepted.

Number certified in 1970-71 _____

Number certified in 1980-81 _____

Of those certified in 1980-81 please indicate the number in the categories listed.

Accepted a teaching position _____

Accepted a non-teaching position _____

Went on to graduate school _____

Do not know status _____

Comments on possible solutions or major factors creating the problem would be appreciated. Return to Harold Huneke, Math Dept., Univ. of Okla, Norman 73019 by April 23. Thanks.

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APPENDIX C

Administrator Comments

"For the past several years have had very few math applicants. Experienced great difficulty last year in trying to fill one math position. Would expect to experience the same or greater difficulty this year."

"Higher salaries - couldn't compete with industrial job salaries."

"It is very difficult to find certified personnel in this area."

"Private industry is robbing us of all qualified teachers. We must get their salaries raised."

"The supply of math and science teachers has been diminishing for the past four or five years and as long as the oil and energy industries siphon off the bright and aggressive among prospective teachers the prospects for available teachers will continue to diminish. We already pay special education, vocational teachers, coaches and the like because of scarcity - the same will also have to apply to these scarce categories."

"Make teaching salaries equal to salaries outside of teaching field."

"I have taught mathematics for 23 years and for the past several years have been superintendent of schools and taught two or three math classes per day. I would like to give those classes to someone else, but have been unable to hire a math teacher for several years. In all my years of teaching I have only produced one student who be-

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came a math teacher - but have started countless students on the way to degrees in engineering and computer science. You cannot give a starting salary of $12,000 per year to someone bright enough to handle math and science and expect them to major in education. If salaries are not competitive with industry - and they definitely aren't - you cannot expect to gain competent young math and science teachers. You'd have to have a real burning desire to work with young people when all your friends are making twice what you do."

"If we are able to make the pay competitive and job conditions better the supply situation will improve."

"Get those salaries up to compete with private business!"

"There are not as many math and science majors in college as in the past (proportionately). Salaries for these people (math/science) need to be increased to compete with industry."

"Math teachers are the second most difficult teaching position to fill, next to science. The quality of math teachers is usually good."

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APPENDIX D

Dr. Joseph R. Weaver, Administrator of Teacher Testing, Oklahoma State Department of Education. Educational background includes B.A. and M.S. in mathematics and Ed.D. from University of Oklahoma in Mathematics Education (1976). Professional experience includes eight years of junior high and high school teaching, six years of teaching at the college and university level, and ten years working in the Oklahoma State Department of Education. The work in the State Department of Education includes nine years as mathematics specialist. Professional membership include Oklahoma Council of Teachers of Mathematics, National Council of Teachers of Mathematics, and Association of State Supervisors of Mathematics. Other professional activities and accomplishments include serving as treasurer, First Vice-President and Program Chairman of the Association of State Supervisors of Mathematics; Vice-President of Louisiana Council of Teachers of Mathematics; speaker at numerous state, regional and national mathematics education meetings; consultant in the planning, design, implementation and inculcation of projects funded by federal grants; director or instructor of workshops and seminars on mathematics education; Oklahoma representative in several national consortiums to develop guidelines and recommendations on instructional materials in mathematics education.

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Dr. Harold Huneke, David Ross Boyd Professor of Mathematics, Ph.D., University of Oklahoma (1957). His professional experience includes three years of high school teaching and thirty years at the college and university level. In 1969-71, he served on the New Delhi, India, staff of the National Science Foundation. Other professional activities and accomplishments include serving as president and secretary-treasurer of the Oklahoma-Arkansas Section of the Mathematical Association of America; president and board member of the Oklahoma Council of Teachers of Mathematics; national secretary-treasurer of Mu Alpha Theta, High School Mathematics Club (1962-present); member, External Affairs Committee of the National Council of Teachers of Mathematics (1975-76; director of several summer and in-service institutes for teachers supported by N.S.F.

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Abbreviated Vita

Dr. Douglas B. Aichele
(pronounced "HL")

Educational Background

Pre-college education: Great Neck, New York
Undergraduate/graduate degrees in mathematics from the University of Missouri-Columbia; doctorate awarded 1969.

Professional Affiliations

Professor of Curriculum and Instruction and Mathematics, Oklahoma State University, Stillwater, Oklahoma

Currently Head of Department of Curriculum and Instruction, OSU

Served five years as Director of Student Teaching and Clinical Experiences at OSU

Visiting Professor of Mathematics, Universidad de Carabobo, Valencia, Venezuela; 1971, 1973

Taught mathematics at West Junior High School in Columbia, Missouri

Member of MAA, NCTM, SSMA

Publications

Authored or co-authored 20 articles, 8 books, and 12 miscellaneous publications. Readings in Secondary School Mathematics is a basic text used at many colleges/universities that prepare mathematics teachers.

Honors/Awards

Selected as Outstanding Teacher of the Year, Oklahoma State University, 1976

Elected President (elect) of the School Science and Mathematics Association, 1981

Recreation

Racquetball, Running
Built a native log cabin in Colorado in Summer, 1975

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Mr. McCURDY. Thank you, Dr. Aichele.

I have been informed by some of my colleagues that because of the time they will not be asking questions. We are running out of time, but I want to have you quickly summarize, perhaps two points, or to make two points. What do you see as the role of the Federal Government? You talk about the NSF, and the Institutes, but do you believe the States will continue to take up the slack? Do you see any help at all at the high school and the precollege or at the early college level of industry support? And also, what is the role of the school boards?

Mr. KELLOGG. I'd like to respond to one part of that. And that is in regard to industry's support to training of science teachers. Industry is not that interested in the training of science teachers. They would like science specialists and, consequently, that is where their money is going to go. So those of us who are in science education and are hoping for a significant amount of support from industry, those that might be somewhat comparable to what we have with NSF, I think it's only a pipe dream and we can forget it.

Mr. WEAVER. I would like to respond just briefly to a couple of your comments.

First of all, about the role of the Federal Government and what can be done nationally. We are fortunate in Oklahoma that we have a surplus of funds and we are putting more money into education every year. But there are States that are not nearly that fortunate.

I talk with my colleagues from other States periodically, and they are in dire straits. And I am not sure what the answer is. I don't know if the Federal Government can bail them out, but I do think that the Federal Government has a role in providing the leadership and helping to make society aware of the problems that do exist.

One of the things that I think that we are going to have to do in Oklahoma, and I am not sure this is a popular thing today to talk about, but I am not sure that we are going to be able to meet the demands for teachers in every school system in the State. And it may be that we have to do some creative organization, cooperative efforts between school districts, in providing advanced classes in which we have one excellent teacher that's employed to teach a course of advanced mathematics, in which students from several school districts in the area come together and meet and take the course under that one teacher.

Another thing that is a possibility, we have teachers who have left the profession and who have entered private business or industry that are still living in communities that could be excellent teachers. It may be that we have to extend our school day and have classes at night.

I have had people tell me that's not practical, but it's certainly better than not training our young people in mathematics.

We are going to have a look at some creative solutions to problems like that. I just don't think we can wait for the numbers of mathematics teachers to develop that we are going to need.

Mr. McCURDY. Thank you, Doctor.

I think Mr. Hall had a quick question.

Mr. HALL. I think, to Dr. Weaver, you spoke of House bill 1706. I'm sure it mentions money, more money for education. It certainly alludes to that because I think that is the answer, and more money for teachers.

What fields do you have an abundance of teachers in? You know, we just finished a school board race in my little hometown and one of the issues was that we had more coaches than the Dallas Cowboys. [Laughter.] I accept the cheers, but it should be stated that upon closer look, most of those coaches also taught. And in small schools, I think you will find that is the situation. Does the bill allude to bonuses for entering into the field of science? Is that a practical answer?

Mr. WEAVER. The bill simply does not offer any bonuses for any particular field. It did increase the pay of all teachers.

The basic components of House bill 1706, however, are related to other things besides teachers' pay. I think that if you look at the numbers of teachers that are being produced by the universities, at least from what I see, and in terms of the people who are taking teacher certification tests, the largest numbers of the areas in which we have the largest number of people are health and physical education, social studies—those are the two largest ones.

Mr. HALL. What do you think of the idea of a bonus to enter into the field?

Mr. WEAVER. Well, I think that's a very unpopular position with many educators, but I think that is an option or a suggestion that has been made by a number of people who responded to our survey. Many of the educators that sent in the survey forms gave this as a suggestion.

And I think that presently for that, we pay coaches more because they have extra duties. We have paid special education teachers more than teachers in other areas. We have paid vocational teachers more than teachers in other fields, and so I think that we are definitely going to have to make some pay differentials for people in these fields.

Mr. HALL. Thank you, Mr. Chairman.

Mr. MCCURDY. Thank you.

Mr. Weber had a question.

Mr. WEBER. I just wanted to follow up on that. Do you really think that in the absence of a solution to the pay problems for science and mathematics teachers, that we can do anything else that is really going to impact on that problem?

Mr. WEAVER. I will say this, and then I will let Dr. Huneke speak to that. I think that there are definitely some other factors that impact on the teacher shortage other than low pay. And I think that the testimony that is included in the opinion from Dr. Harold Taylor speaks to that. He is a high school mathematics teacher who taught for many years.

He testified before the National Committee on Excellence, and what he said was that in effect, that teachers have to put up with a lot of problems that relate to loads and numbers of pupils taught, paper grading, and discipline problems and these kinds of factors. And I think that these are societal problems. And I'm not sure that we have the answer for them, but I think that the involvement of

the whole society and the problems that the teaching profession is facing has a great deal to do with answering this problem.

Dr. HUNEKE. I have a personal reference. My daughter-in-law taught in Jenks, Okla., just outside of Tulsa. About 4 or 5 years ago she went to a Christmas party and got to chatting with an employee from IBM.

Our daughter-in-law was happy teaching; she enjoyed it. She decided to go for an interview with the thought, "Well, next summer I might work for IBM and make a little extra money." She went down and interviewed with them and they offered her a job. At the start of the second semester she started with IBM at a $5,000 increase in salary, medical benefits paid by the company, a $5,000 life insurance policy, and an automatic stock option.

She enjoys teaching. She's working for IBM. Her salary has probably doubled her teaching salary since she started. Some days she says, "I might like to go back to teaching."

I think our society has changed so much in the last few years that money indicates what we value. You know, I used to believe that teachers were something like missionaries; there was a call to teaching. And I still do, seriously; that is, I still believe that element exists. But I do believe money is going to have to say that teaching is important in our society.

If somehow teachers could have employment through the summer months, you wouldn't have a problem. If teachers could be guaranteed an additional 2 months of their academic salary for 2 months of work during the summer I believe we would be able to retain many more teachers. But I do believe, and I regret this, that the answer has to be more money.

Dr. AICHELE. Could I just say one thing?

Mr. MCCURDY. Yes.

Dr. AICHELE. I wanted to pick up on what Dr. Weaver said concerning some of the issues other than pay.

In a 1981 Gallup Poll report which appeared in Phi Delta in October of 1981 is the most recent conglomerate of a wide survey illustrating the factors that impact on education. And I think that if you had an opportunity to look at that you would see that the issues of money are important, but there's a lot of other things, one of which is the home attitude toward the teaching profession, in general.

That's all I had to say. Thank you.

Mr. MCCURDY. Thank you.

Jim, I think the missionaries are getting nervous and are anxious out there. [Laughter.]

I know these missionaries are up here too.

I would like to again, apologize for the time constraints. I would invite each of the panel members, of course, to join us for lunch and the afternoon session and to be available for questions from the audience.

There are a couple of quick announcements. First of all, there have been a number of people who asked if they could obtain copies of House Resolution 5254, and there is a signup sheet out at the registration desk. And if you will just leave your name and address, then my office will be glad to get copies of those to you.

Now, we will have a luncheon. It is at Couch Center, which is directly across the street, or it's in walking distance anyway. We can all walk together as a group over there.

We have an excellent speaker for the luncheon. I think you will certainly enjoy him.

Let me take just a quick opportunity, if I might, to thank a couple of people. First of all, Dr. Maxwell, here, who came. He is on the staff, and has taken an unusual effort to make this hearing possible. Also Suzy Leonard on my staff who has dedicated a lot of her time, and I think valuable effort, in putting this all together. And Mr. Rheem, who has worked—and each of the staff—well, everything you see here is a culmination of about 10 times that much staff work that goes into making these things available. But also I must commend my colleagues for taking the time and effort to come.

The mere fact that Members of Congress, on a very, very—believe me, a very, very busy schedule, will take their time out when they could be in their districts working in other ways in an election year, I might add, to come to Oklahoma where there are no votes for them, to demonstrate their concern for this problem; I think that's very remarkable. And the fact that we have three from out-of-State to come to Oklahoma, shows the concern that they have for this problem.

It is also, I think, fitting that we had a congressional hearing in a classroom. Not all government is operated and conducted in Washington, D.C. as it is at the grassroots level. That is very important.

Again, I appreciate your attendance at this meeting, and with that, we are adjourned.

[Whereupon, at 12:15 p.m. the subcommittee adjourned, subject to the call of the Chair.]

[Additional statement for the record follows:]

TESTIMONY

PRESENTED BY

SARAH E. KLEIN
PRESIDENT
NATIONAL SCIENCE TEACHERS ASSOCIATION

The following testimony is presented by Sarah E. Klein, President of the National Science Teachers Association (NSTA). The NSTA is the largest science education organization in the world. It is the only science education organization that is concerned with the professional aspects of science education at all levels and for all science disciplines.

Mrs. Klein is an 8th grade general science teacher at Roton Middle School, Norwalk, Connecticut. She is currently on leave to carry out her responsibilities as President of NSTA. Mrs. Klein has been active in NSTA for many years, and over the past year has visited schools, talked to teachers, and participated in numerous science meetings throughout the United States, Canada, England, and France. Mrs. Klein wishes to acknowledge the efforts of Bill Aldridge, Executive Director of NSTA, and of James Shymansky, of the University of Iowa, in the documentation and preparation of this testimony.

The Dual Missions of the National Science Foundation

The dual missions of the National Science Foundation are to strengthen the scientific research and science and engineering education capabilities of this nation.

> "The Foundation is authorized and directed (1) to initiate and support basic scientific research and programs to strengthen scientific research potential and science education programs at all levels. . ." (NSF Act of 1950.)

Since 1959, when the science education component of NSF accounted for about one-half of the entire NSF budget, the science education share has been systematically reduced to its low of 7.5% in 1980. With the budget proposal of March 10, 1981, the OMB began a process which would totally eliminate programs of the science education component of NSF, thereby changing the mission of this agency from its dual purposes of strengthening scientific research and science education to just research.

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Of the $20.4 million appropriated for NSF science education for 1982, $15 million was for graduate fellowships. Some $700,000 was designated to support a "commission," and the balance was used to meet "prior obligations."

Staff of the Science Education Directorate have already been reduced from over 100 to about 50, and within the next few months, will be reduced to 10 or 12 persons. Since graduate fellowship support is but another form of support for scientific research, the NSF has essentially eliminated all science education activities. The Administration has successfully forced NSF to abandon one of the missions required by its enabling legislation. It is time that NSF either ask Congress to change the organic act and delete science education from its mission or stop the deception that graduate student support alone is somehow equivalent to support of science education at all levels and proceed with its responsibilities by providing a budget which addresses serious national problems in science education.

The Special Commission on Science and Engineering Education

The only new activity for science education in the 1982 budget was $700,000 to support a special commission on science and engineering education. The draft charter for this commission would have it duplicate studies already undertaken, but largely ignored. The NSF spent upwards of $3 million over the past five years for such studies. There already is ample evidence of what the problems are and what is needed to solve them. The problems are not solved by additional studies. What is needed is federal action to address documented and serious national problems. A major problem, like the crisis in secondary science education, which is national in scope, cannot be broken into 50 smaller problem pieces and sent back to the states to solve. Both the commission charter and the National Science Board policy statement that brought the commission into existence specifically recognize that NSF programs could result from work of the commission. However, the proposed 1983 budget has no funds to act

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on recommendations of the commission. Indeed, there are not even funds to continue the commission itself. One can only conclude that this commission is but another gratuitous, empty gesture toward meeting NSF's obligations to science education.

The Crisis in Secondary School Science and Mathematics Education

Our nation faces unprecedented problems in science and engineering education. Most severs of these problems are at the secondary school level where there is a critical shortage of qualified science and math teachers. The paucity of supplies, resources, appropriate materials, and support have reduced the quality of science and math education at the secondary school level to a point that national security and the nation's efforts toward improved productivity are dangerously threatened.

Shortages of Secondary School Science and Math Teachers

In 1980 and again in 1981, surveys were conducted by Howe and Gerlovich (1) of the 50 state science supervisors to assess supply and demand for secondary school science and math teachers. Shortages of science and math teachers were found to exist in 1980, and those shortages became more severe in 1981. As shown in Table I, this problem is national in scope, and the shortages are critical in physics, mathematics, and chemistry.

Number of States Reporting in 1980 and 1981

	Critical Shortage		Shortage		Adequate Supply		Surplus	
SUBJECT	1980	1981	1980	1981	1980	1981	1980	1981
PHYSICS	21	27	22	15	3	4	2	1
MATH	16	18	19	25	7	2	4	1
CHEMISTRY	10	9	25	29	9	6	5	2

TABLE I

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Another survey of placement officers conducted by James Akin (2) in 1980 showed similar results. "Considerable shortages" of teachers were found for math, physics, chemistry, and general science.

Severe Decline in Numbers of Persons Prepared to Teach Science and Math

In December, 1981, the NSTA surveyed 600 colleges and universities that have teacher training programs (3). We wanted to find out what has been happening to numbers of newly trained science and math teachers. Year-by-year data were acquired for the ten-year perod of 1971 - 1980. The results shown in the appended graph #1 are shocking. There was a 78% decline in the average number of math teachers and a 64% decline in the average number of science teachers prepared to teach in secondary schools.

Employment of Unqualified Science and Math Teachers

In another NSTA survey (4), also conducted in December, 1981, and analyzed by James Shymansky of the University of Iowa, secondary school principals provided the information. Among newly employed science and math teachers, 50.2% were unqualified to teach science or math. They were employed on an "emergency basis" because no qualified teachers could be found. When these data are examined by census regions, the results are especially bad in states where high technology industries require the best-trained science and math personnel. Table II shows, by census region, the percentages of newly employed science and math teachers last year who were unqualified to teach these subjects.

Census Region	Percentage of Newly-Employed Science and Math Teachers Who Were Unqualified
Pacific States	84%
Mountain States	23%
West North Central States	43%
West South Central States	63%
East North Central States	46%
East South Central States	40%
North East States	9%
Atlantic States	43%
South Atlantic States	50%

TABLE II

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Ages, Experience, and Plans of Science and Math Teachers

The evidence of a severe shortage of science and math teachers at the secondary school level is overwhelming. To compound this problem, results of the NSTA survey of science teachers show that schools have an aging faculty and that one in four of the younger faculty plan to leave teaching completely. The average age is 41, and the average experience is 16 years. Almost 5 times more science and math teachers left teaching last year for employment in non-teaching jobs than left due to retirement.

Conclusions about Teacher Shortages

Independent recent surveys all show a severe shortage of secondary school science and math teachers. There has been a catastrophic decline in the number of persons prepared to teach science and math, and of those prepared, many do not take teaching positions. Secondary schools are employing record numbers of unqualified persons for science and math teaching positions because qualified persons cannot be found. The problems are most severe in regions of the country where the greatest efforts will be made for defense preparedness and high technology industry. Thus there is a dangerous mismatch between scientific and technological training capability and national need.

Quality of Science and Mathematics Education

The severe shortages of secondary school science and math teachers, and the resulting employment of unqualified teachers on an emergency basis is a major factor in the decline of quality in secondary school science and math education. For the teachers who remain in the science and math classroom, there are other constraints which have made the situation deteriorate further.

From the recent NSTA survey, we know that 60% of the science teachers report cuts in their budgets for supplies and equipment. These cuts occur

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at a time when school labs are already obsolete, and when computers and other components of modern electronics are essential in an up-to-date curriculum.

From the same survey, we learned that 79% of these teachers had not completed at least a 10-hour course or workshop in over ten years. Also, 69% have never attended a computer course or workshop. Finally, 40% have not attended a course or workshop since they began teaching, an average of 16 years.

In another recent national survey conducted by NSTA, elementary school teachers provided the responses (5). Approximately 51% report that their undergraduate training did not give them any preparation to teach science. Furthermore, 71% have never had inservice training for science, and 64% no longer had science consultants assigned to their schools.

There has been much public discussion of declines in SAT scores, but less attention has been given to declining scores in the national assessment. There has been a decline in recent years, and now those declines are affecting even our best science and math students.

Prior NSF Support of Science and Engineering Education

There is, among those in the Administration, and among many others, the mistaken belief that science education has received substantial support, especially in recent years, and that since we now see all of these serious problems, the infusion of massive federal support has been a failure. The facts are quite the opposite. The NSF support for science and engineering education has been declining steadily and steeply for the past 22 years. The appended Graph #2 shows how science education's share of the total NSF budget has dropped from a high of 47% in 1959 to its present low of 2%.

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Support for pre-college science education has dropped even more sharply, from 72% of the science education budget in 1959 to 22% in 1980. In terms of the total NSF budget, the pre-college share has dropped from 34% in 1959 to its present low of less than 1%.

The NSF support for secondary school science and math has fallen to a negligible level, and the present cluster of national problems in secondary school science and math education can in large part be attributed to NSF's negligence of this component of their Congressionally mandated mission. The appended Graph #3 shows how the decline in NSF support at the pre-college level correlates with declining achievement in science as measured by the National Assessment of Educational Progress.

NSF Curriculum Development Projects

Much of the demise of NSF's science education support has resulted from criticisms of curriculum development activities.

There are legitimate criticisms that one can make of the "new curricula" produced under NSF support: These projects often purged applications, concentrated heavily on pure science, and appealed mainly to the brightest students. Their difficulty level contributed to the reduction in the numbers of students studying science and mathematics in recent years.

According to preliminary results of a very recent study (6), the new curricula were far more successful than most people realized. In this NSF-supported project (SED 80-12310), directed by Ronald Anderson of the University of Colorado, and carried out by James Shymansky of Iowa, an analysis was made of 105 studies involving 45,000 students. Comparisons were made between students enrolled in new science curricula and traditional curricula. On every kind of measure, including achievement, attitude, and process skills, students taking the new NSF curricula scored overall 13% higher. For the BSCS Biology and Chem Study

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materials, the students scored higher by more than 17%. What is most significant is the fact that students from low socio-economic groups scored 24% higher using new NSF-supported curricula than traditional curricula. Thus, since a larger proportion of our minority population are in the low socio-economic categories, the new curricula, supported by NSF, gave minority children a decided edge over similar children exposed to traditional materials.

These studies covered a period of several years in the 1960's and 1970's. Few teachers are left in the schools now who are qualified to teach such curricula, and essentially none have been given the in-service training to do so since NSF abandoned that kind of program several years ago. Also, the materials are badly in need of revision and modification to take into account computers, modern electronics, and applications to technology. The problem of offering appropriate science to less able children also must be addressed.

Comparisons of U.S. and U.S.S.R. Science and Math Education

Recent comparative studies (7) in science and engineering education between the Soviet Union and the United States suggest a major offensive by the U.S.S.R. to increase its economic productivity and defense preparedness through science and engineering education. The U.S.S.R. offers its precollege students sequences of course material in science and mathematics starting with an intuitive level of understanding. Then students progress to empirical levels; finally, they are ready for the formal axiomatic and theoretical understandings. The actual time spent begins with only a couple of hours per week and changes gradually over three or four years until students spend four to five hours per week in class. Thus the Soviets not only offer all students quantitatively more contact with the sciences and mathematics, they do so systematically to ensure that students progress in a way that matches stages of intellectual development. In U.S. secondary schools, and in colleges, students enter

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a course in physics or chemistry and are immediately introduced for the first time to the highest levels of abstraction, without any intuitive basis or prior empirical knowledge. Thus many find these subjects hopelessly difficult and fail or drop out. Most students simply avoid taking these subjects, having heard how difficult they are. The lack of application in science curricula and their failure to relate to personal and societal problems and issues further alienate students.

An NSF Science and Engineering Education Component for 1983

Given clear and conclusive evidence of serious national problems in science and engineering education, what specific programs can the NSF undertake in 1983 within the constraints of the proposed budget?

The most critical problems are at the pre-college levels, especially in secondary school science and mathematics. Those problems are, in order of priority:

1. Critical shortage of physics, mathematics, and chemistry teachers at the secondary school level;
2. Substantial numbers of unqualified persons are teaching science and mathematics in secondary schools;
3. New sequences of science and math courses and materials are needed which match stages of intellectual development of children;
4. Even certified science and mathematics teachers at the secondary level are badly in need of in-service training;
5. Elementary and secondary schools need access to microcomputers and low-cost supplies and other resources;
6. Science curricula need revision, and teachers need training in using new materials and new methods of sequencing content; and

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7. Elementary school science consultants are needed who understand science, stages of intellectual development of children, and who know what resources are available.

The critical shortage of secondary school science and math teachers cannot be solved in 1983. This problem is closely related to the problem of unqualified and marginally-qualified teachers who are now teaching science and mathematics. Because there are overall reductions occurring in the numbers of teachers needed in some other fields, many of the newly-appointed, but unqualified science or math teachers are recruited from these other areas.

The long-term shortages must be addressed by stimulating new entrants to teacher training programs in science and mathematics. This can be accomplished through NSF scholarships and NSF-supported programs of publicity on the need for teachers.

In the short term, the NSF should support summer and academic-year courses and workshops for marginally-qualified science and math teachers, so that they may reach some minimal level of qualification to teach the assignments they have been given. The level of support should be limited to grants for tuition, books, and materials, up to a maximum of 20 semester hours' credit equivalent per year. No support should be given to colleges for this program, since the tuition grants provide indirect support and cover the costs of that instruction.

The problem of establishing new sequences of science and math courses to match the stages of intellectual development of children is most difficult to solve.

The most cost-effective solution would be for the NSF to support development and implementation of a model sequence in two or three school systems. These models would be carefully developed in cooperation and

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with assistance of scientists and science education experts at universities. Detailed guidelines for establishing the sequence would be prepared and widely disseminated. The NSF would provide support only for consultant services to schools that chose to implement the approach following the guidelines which had been developed.

The problem of upgrading qualified science and math teachers can be solved by offering short courses and workshops. The NSF has models of these already in operation and could easily continue these programs.

The need for low-cost supplies and other resources can be addressed by NSF through a program of support for area Science Instruction Resource Centers, modeled after the one created by Douglas Lapp in the Fairfax, Virginia School District.

Microcomputers could be supplied through an NSF program of partial support. Even a level of support by NSF of 25% of the cost could have great leverage in bringing larger numbers of microcomputers into the schools. Given the availability of in-service programs for teachers, proper utilization could be assured.

The revision of curricula to bring them up to date and to accommodate to the new technology, applications, and societal problems, can be accomplished through conventional, but carefully monitored, curriculum development projects.

The problems of elementary school science are immense, but a high-leverage approach, with relatively low cost, would be an NSF program of summer and in-service studies for science consultants. Also, some modest grant support could be provided to school districts that were willing to reinstitute a science consultant program for their elementary schools.

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Does the American Public Think that Tax Funds Should be Used by NSF to Support Science Education and Basic Research or Just Basic Reseach?

The Thirteenth Annual Report of the National Science Board, Science Indicators 1980, dated March 31, 1981, offers much interesting and useful information.

The table below is taken from that NSF report. According to this report to the President, the Public would rank science education second as its choice "to receive science and technology funding from tax money." The public would rank basic scientific research tenth in its choice to receive such tax money.

SCIENCE EDUCATION RANKED 2nd -- BASIC SCIENTIFIC RESEARCH RANKED 10th!

Given clear evidence of public preference for spending tax money for science education over spending it for basic research, and given the Congressional mandate in the organic act of NSF to support science education at all levels, it is most difficult to understand why NSF is forced to neglect this responsibility.

Appendix table 8-10. Areas the public would most like to receive science and technology funding from tax money: 1972-79

Area	Percent in 1979	Rank[1] 1972	1974	1976	1979
Improving health care	50	1	1	1	1
Developing energy sources and conserving energy	46	([2])	([2])	([2])	([2])
Improving education	39	5	4[3]	3[3]	2
Reducing crime	36	3	2	2	3
Developing or improving methods for producing food	23	([2])	([2])	([2])	([2])
Reducing and controlling pollution	22	2	3	3[3]	4
Developing or improving weapons for national defense	16	10[3]	11[3]	8[3]	5[3]
Preventing and treating drug addiction	16	4	4[3]	5	5[3]
Developing faster and safer public transportation within and between cities	13	7	7	7	7
Improving the safety of automobiles	9	6	6	6	8
Finding better birth control methods	9	8	9	8[3]	9
Discovering new basic knowledge about man and nature	8	9	8	10	10
Exploring outer space	6	10[3]	11[3]	11	11
Predicting and controlling the weather	4	10[3]	10	12	12
	(N = 1,635)				

[1] In 1979, respondents were asked to limit themselves to three areas, and slight changes in the wording of some items were made.
[2] "Developing energy sources and conserving energy" was not included in the listing prior to 1979 and "developing or improving methods for producing food" was not included prior to 1978. These areas were therefore omitted from the rankings.
[3] Tied for the indicated rank.

SOURCES: *Attitudes of the U. S. Public Toward Science and Technology*. Study III (Princeton, N.J.: Opinion Research Corporation, 1978), pp. 56-57; Jon D. Miller, Kenneth Prewitt, and Robert Pearson, *The Attitudes of the U.S. Public Toward Science and Technology* (Chicago: National Opinion Research Center, University of Chicago, 1980), p. 13.

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Where are the Funds for Science and Engineering Education?

The Administration's proposed NSF budget calls for a total of $1,072.8 million in 1983, an increase of 7.7% over 1982. Needed science education programs would be financed by holding the total research and related activities budget to a 2% increase instead of the 8.7% increase which is proposed. This will free up $65.5 million for science education activities.

NSF Science and Engineering Education
Recommended Program Elements for 1983

NSF Undergraduate Scholarships for Math and Science Teaching (4,000 @ $1,500 each)	$6.0 million
Science and Math Teaching Careers Publications and Dissemination	1.5 million
Tuition, Books, and Materials for Summer and Academic-Year Courses and Workshops (5,000 marginally-qualified teachers @ $2,000)	10.0 million
Model Sequences for Science and Math Courses (3 projects @ $2 million)	6.0 million
Short Courses and Workshops for Upgrading Qualified Science and Math Teachers (10,000 teachers @ $1,000)	10.0 million
Model Science Instruction Resource Centers (50 @ $200,000)	10.0 million
Partial Support Grants for Microcomputers (25% of $2,000 for 10,000 schools)	5.0 million
Curriculum Revision and Enhancement Projects	12.0 million
Programs for Science Consultants for Elementary Schools	5.0 million
TOTAL	$65.5 million
Graduate Fellowships	15.0 million
TOTAL	$80.5 million

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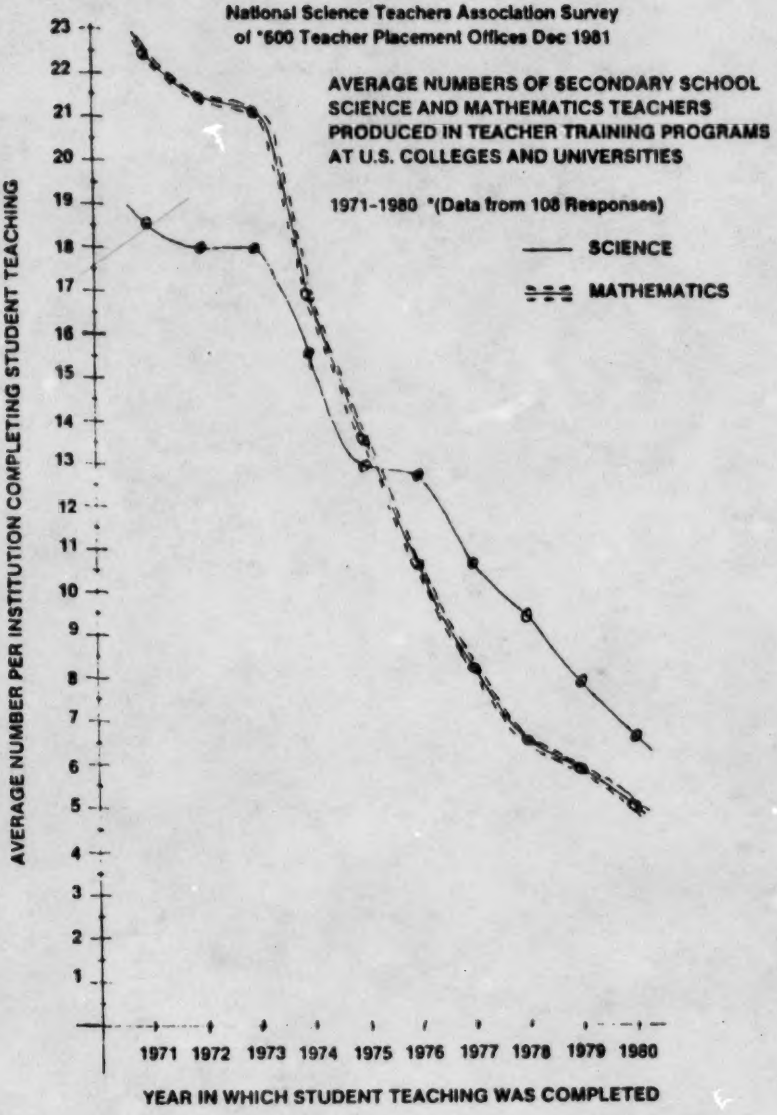

GRAPH #1

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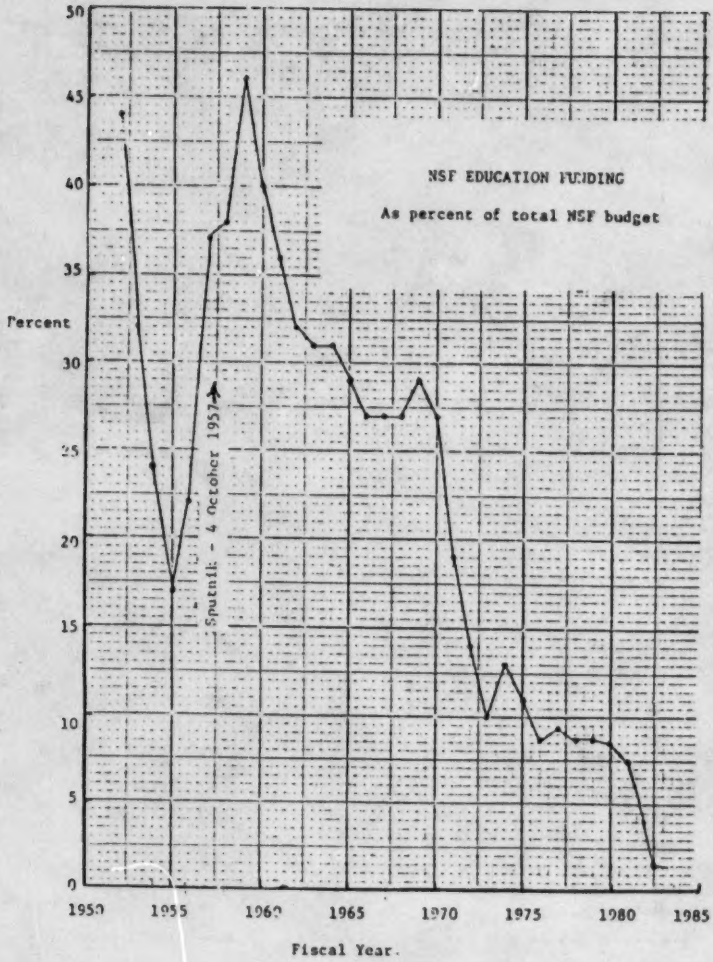

GRAPH #2

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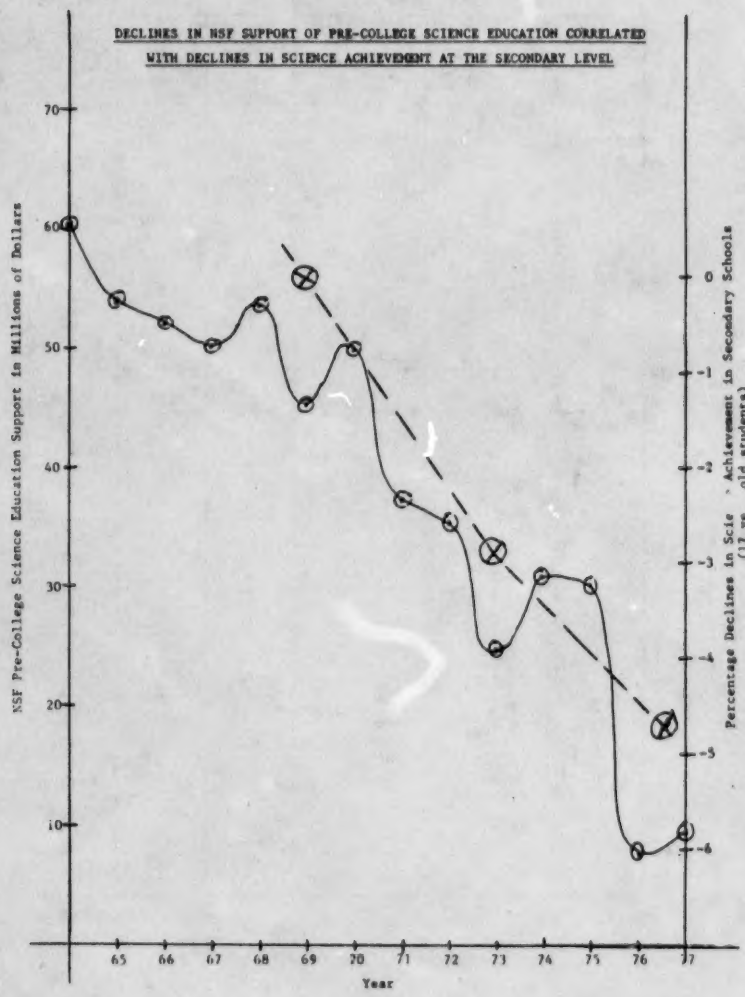

GRAPH #3

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Sources

(1) T. G. Howe and J. A. Gerlovich, "National Study of the Estimated Supply and Demand of Secondary Science and Mathematics Teachers," Unpublished Paper, November 6, 1981.

(2) J. N. Akin, "Teacher Supply and Demand: A Recent Survey," (ASCUS, Box 4411, Madison, WI 53711) 1980.

(3) Preliminary results of December, 1981, NSTA Survey of 600 Colleges and Universities with science and math teacher training programs.

(4) Random sample of 2,000 U.S. secondary school principals in December, 1981. Analysis done by Dr. James Shymansky using staff and computers at University of Iowa.

(5) Preliminary results of survey undertaken in January, 1982, by Kathleen M. Donnellan, NSTA Preschool/Elementary School Division Director, Springfield Massachusetts Public Schools.

(6) C. P. Ailes and F. W. Rushing, The Science Race: Training and Utiliza- of Scientists and Engineers, U.S. and U.S.S.R., Chapters I, II, (Crane Russak, New York) 1982.

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